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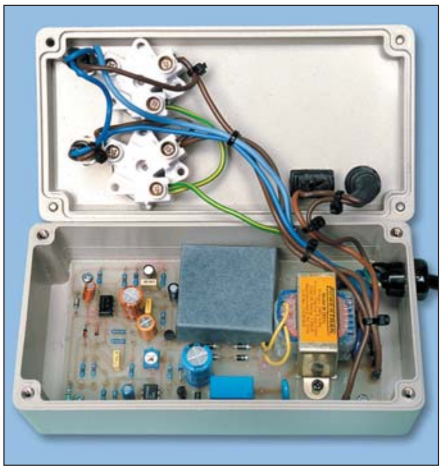

Projects and Circuits

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Our April 2006 issue will be published on Thursday, 9 March 2006. See page 80 for details

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The Father Of *PE* and *EE*

Fred Bennett, the father of *Practical Electronics* and *Everyday Electronics*, has sadly died aged 85 after fighting cancer for many months. He leaves an invalid sister, Dorothy, who he had looked after for most of his life, and a nephew, the son of his second sister who died some time ago. A quiet, private man, dedicated to his sister, Fred never married. He was widely read, an experienced amateur geologist and a member of the Dickens Society.

Fred was involved in the launch of *Practical Electronics* in 1964 and later launched *Everyday Electronics* in 1971 (he had previously worked on *Practical Wireless*). He edited both magazines until *Practical Electronics* was relocated to Poole in Dorset in 1977 after which he continued the editorship of *Everyday Electronics* until he retired in 1986.

It was Fred who decided the strategy of both *PE* and *EE*. In his quiet unassuming way he meticulously planned their development. I never knew him to be angry or to flap in a crisis; he was a gentleman of the old school and he had a way of getting things done without seeming to do anything. He was liked and respected by staff, contributors and readers alike.

It was Fred that instigated the *Teach-In* series, the first being in the very first issue of *EE* in November 1971 – as you know the bi-annual series is still running some 34 years and 17 series later. It has certainly stood the test of time and has been responsible for introducing many tens of thousands of readers to our hobby and to careers in electronics.

Fred was responsible for setting the standard that made the magazines so sucessful, particularly through the seventies when the circulation of each magazine was well over 100,000 copies. He was responsible for offering me a job, for promoting me to assist with the launch of *Everyday Electronics* and teaching me how to help produce the first class magazines he had developed. I have much to thank him for, as no doubt have many who have been inspired by Fred's magazines – magazines which have survived for over 40 years.

Our condolences to those he leaves behind.
Rest in peace Fred.

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just \$15.99US (approx £9.50) per year available from **www.epemag.com**

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READERS' TECHNICAL ENQUIRIES

E-mail: techdept@epemag.wimborne.co.uk

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons. We are not able to answer technical queries on the phone.**

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

News . . .

A roundup of the latest Everyday News from the world of electronics

SONY'S XCP FIASCO AGAIN

Barry Fox has the latest on Sony's Gaff!

Sony's public apology for releasing music CDs with rootkit copy-protection software – that left PCs vulnerable to viruses – came late and tried to shift the blame. But the XCP (Extended Copy Protection) fiasco (reported last month in *Techno-Talk*) has already had the highly beneficial side effect of making the music industry a lot more careful over what it hides in CDs.

The reason is quite simply money and face. It has cost the Sony BMG record label tens of millions of dollars to undo the damage done; court case claims against Sony BMG are still pending; and Sony has lost face, which means even more than money to a Japanese company.

It is good news too that the XCP problem was revealed by computer expert Mark Russinovitch (**www.sysinternals.com/blog/2005/10/sony-rootkits-and-digital-rights.html**) before any of the 52 infected titles were released in Europe. So far there have been no sightings of official or unofficial XCP imports in the UK. But it pays to stay on your guard because, as Russinovitch explains, the rootkit is very hard to remove from a PC without completely re-formatting the hard disc.

Millions Re-called

Sony has had to recall 2·7 million unsold discs from retailers, and 2·1 million already sold to consumers. The discs are being replaced with CDs which do not use XCP, but this is taking up to six weeks. Major artists including Neil Diamond, Frank Sinatra, Burt Bacharach, Celine Dion and Bette Midler will inevitably suffer from lost sales.

The artists, their estates and managers are reportedly furious with Sony. Because Sony is offering free collection and delivery by the UPS service, the cost of carriage alone will be up to $20 million. Industry analyst company Gartner has published a report that XCP can be defeated anyway.

"The user simply applies a fingernail-sized piece of opaque tape to the outer edge of the disc, rendering Session 2 – which contains the self-loading DRM software – unreadable," says Gartner. "Sony BMG has created serious public-relations and legal issues for itself, and for no good reason".

It took more than a week for Sony to own up and publish a buck-passing apology. "We deeply regret any inconvenience", says Sony's open letter to "our valued customers (but) the software was provided to us by a third party vendor, First4Interne".

This reads as a damning indictment of Sony's computer division, which did not spot the problem either before or after the discs were released.

Sony's FAQ

At the height of the trouble the software vendor's web site was still promoting XCP as "the true meaning of audio security". (**www.first4internet.co.uk/**). Sony's web site offers thirteen pages of Frequently Asked Questions on how to remove XCP protection with a "malicious software removal tool". (**http://cp.sonybmg.com/xcp/english/faq.html**). But Sony has neglected to offer a printer-friendly version. So unless Sony's "valued customers" know the trick of setting their printers to Landscape instead of Portrait, the right hand side of the printed text will often be missing.

As a direct result of Sony's humiliation, US company SunnComm has now acknowledged that its MediaMax Version 5 software "used on another 27 CDs from Sony BMG" has a "security vulnerability". SunnComm has now released a software patch to address the problem (**www.sonybmg.com/mediamax/titles.html**).

Sony's problems with XCP and SunnComm made news just as Macrovision, world leader in audio and video copy protection, was offering the record companies another new DRM system called Total Play. This was developed by Midbar, the Israeli company which Macrovision bought after Midbar hit problems with its original copy-protection system, called Cactus Data Shield. Some Cactus discs would not play on some CD players.

Macrovision recently demonstrated Total Play with test tracks recorded by EMI pop group Gorillaz. When the CD is put in a PC it plays with pictures, games and video, also providing the opportunity to copy the music to a PC with a choice of Windows Media Digital Rights Management or Sony's Atrac/OpenMG DRM.

Yoav Elgrichi, Macrovision's Senior Program Manager for Music Content Management assured recently: "The disc is fully compatible with the Red and Yellow books; and it's Microsoft certified".

Sony's high profile gaffe could work for or against Macrovision. The music industry may simply not dare use DRM of any type – or the record companies may turn to Macrovision because of the company's proven track record on rigorously testing copy protection on banks of consumer players before releasing any protected recordings for public sale.

Ring It Yourself!

Cellphone users round the world spend a billion dollars a year on downloading musical ringtones. So the music industry may not be too pleased with a new "fun way to save serious money" by making ringtones "in seconds ... without fees, subscriptions or downloads".

Magix Ringtone Maker is a £20 PC program that rips music from a CD or MP3 file, converts it to ringtone format and dumps it direct into a phone (**www.fast-track.co.uk**). The software also allows editing to cut a song down to ringtone length.

"It makes an ideal present for teenagers", says FastTrack. But to stay legal users should obtain 'express permission' from record companies before ripping."

Barry Fox

SMALLER CAMERA PHONES

How can camera phones that play music possibly get any smaller, without compromising the optical or sound quality? Sony Ericsson has a neat idea. It's revealed in a recent patent filing from Sweden (WO 2005/114990). The camera lens is built into the centre of the speaker cone, so the image sensor is behind the speaker and "looks" through it. Because the cone and lens share space, they can both be larger.

As a spin-off bonus the lens is focused by moving the cone – which is easily done because a moving coil cone is designed to be moved fast to play music and can just be moved more slowly and then frozen still for a moment to focus and take a picture. Presumably the phone can't play music while taking a picture but that is unlikely to be a problem in practice for most users.

Barry Fox

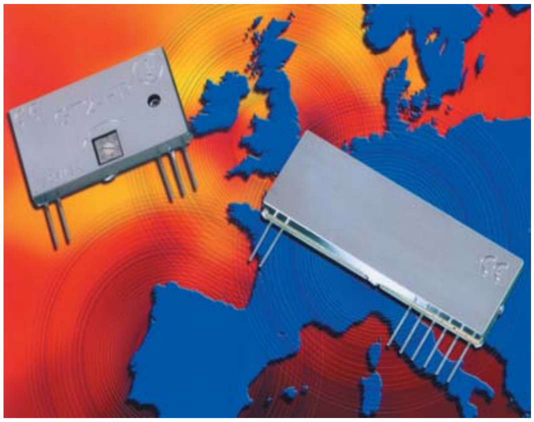
HARMONISED RF MODULES

MK Consultants have introduced a range of radio modules designed for operation in a new pan-European frequency band that spans 169·4MHz to 169·8MHz. The Genesis 2 family of transmitter and receiver modules combines low cost with high performance in applications such as social alarms, asset tracking, meter reading and paging.

The GT2 transmitter module delivers 10mW of power, whilst the GT2HP allows designers to select the appropriate power level for their application via its adjustable 5mW to 200mW output. The modules use accurate and reliable narrow band crystal technology and achieve data rates of up to 9600 bits/s. A wide choice of preset frequencies is available, making the modules ready for use in specific types of application. Modules with custom frequencies can be supplied on request.

The receivers are housed in fully shielded SIL packages and feature analogue, digital and true RSSI outputs. Supply voltage can range from 2·7V to 10V. All modules in the Genesis 2 range have an operating temperature range of -10°C to +55°C and are EN 300-220-1 compliant.

For more information contact MK Consultants (UK) Ltd.,Dept *EPE*, 288a-290 Queens Road, Halifax, West Yorks, HX1 4NS. Tel: 01422 329002, fax: +01422 353153,. email; mo@mkconsultants.prestel.co.uk, web: **www.mkconsultants.co.uk**.



3D MOVIES

Watch out for Disney's new movie *Chicken Little*, which is showing in 3D in some cinemas. The 3D system is digital and developed by Dolby with US company Real D.

A DLP micro-mirror video projector flashes an alternating series of left and right eye images on screen, each at three times the normal 24 frames per second film speed. So in the time normally taken for one frame of film there is a rapid sequence of L, R, L, R, L, R images. A polarising filter over the projector lens is electrically switched in step with the left and right images and the screen is silvered to preserve the polarisation.

The audience wears passive spectacles with a different polarising filter over each eye. The left and right eye views switch so rapidly that the effect is flickerless 3D. Until now Hollywood has had to use two 24fps projectors for 3D, one for the left eye pictures and one for the right. If the film in one projector broke, the projectionist had to splice the ends together with just enough blank film to fill the gap and keep the two projectors in step.

The DLP projector is getting its pictures from a computer hard drive so there is no film to break and no problem over keeping the images perfectly synchronised. The much higher display rate makes for smoother blending of the L/R images, and less viewing fatigue.

Barry Fox

Recorder in the Mic

New technology unveiled by at least three manufacturers at the *AES Convention* in New York recently shows a sea change coming in radio reporting – and probably concert bootlegging too. Reporters can already buy a jostle-proof recorder that uses solid-state memory instead of tape or Mini-disc. But it still needs a separate microphone and connector lead.

The new trick is to build the recorder into the microphone. Kudelski of Switzerland is ready to launch the Nagra ARES-M, a high quality mono microphone with built-in 1GB recorder. The 12·7mm x 50mm x 2·5mm (5 × 2 × 1 inch) device looks like a small flat sound meter, with a small display and cursor button controls. A clip-on mic capsule converts it to stereo.

Costing around $975 the Nagra mic-rec records either 16-bit linear PCM at 48kHz, or compressed MPEG Layer II. Recording time ranges from 1hr 26mins in top quality stereo to 34hrs 43mins of mono at 64kbps.

Power comes from two AA cells that last for 10 hours. Some audio editing can be done onboard; for more flexibility the mic-rec has a standard USB port for connection to a PC, laptop or studio hard disc editor. Pro industry specialist HHB has a competing product for around $1250.

The FlashMic DRM85 looks just like an ordinary studio cardioid, and also has 1GB onboard memory and USB connector for PC editing. Recording is mono only and formats range from 48kHz linear PCM to 32kHz MPEG1 Layer II at 32 kHz.

Sony was showing an early sample of a stereo mic-rec that has 4GB on board, expandable with a 4GB high speed Memory Stick, and works up to 192kHz 24-bit linear. The device looks more like a flat-pack sound meter than conventional mic.

Barry Fox

ALL-ROUNDER CHARGER KIT

Compit have introduced a new battery charge kit, the C2. They say that it's for all MP3 users and digital photographers and that it consists of a charger, two AAA NiMH batteries of 900mAh and two AA NiMH batteries of 2500 mAh.

Due to adding both AAA and AA size NiMH batteries to the charger, the C2 is a real all-rounder. One AAA and one AA battery can be charged together at the same time, and NiCd batteries can be charged as well. The charger has one LED for each battery compartment.

For more information on Compit, browse **www.compit.biz**.

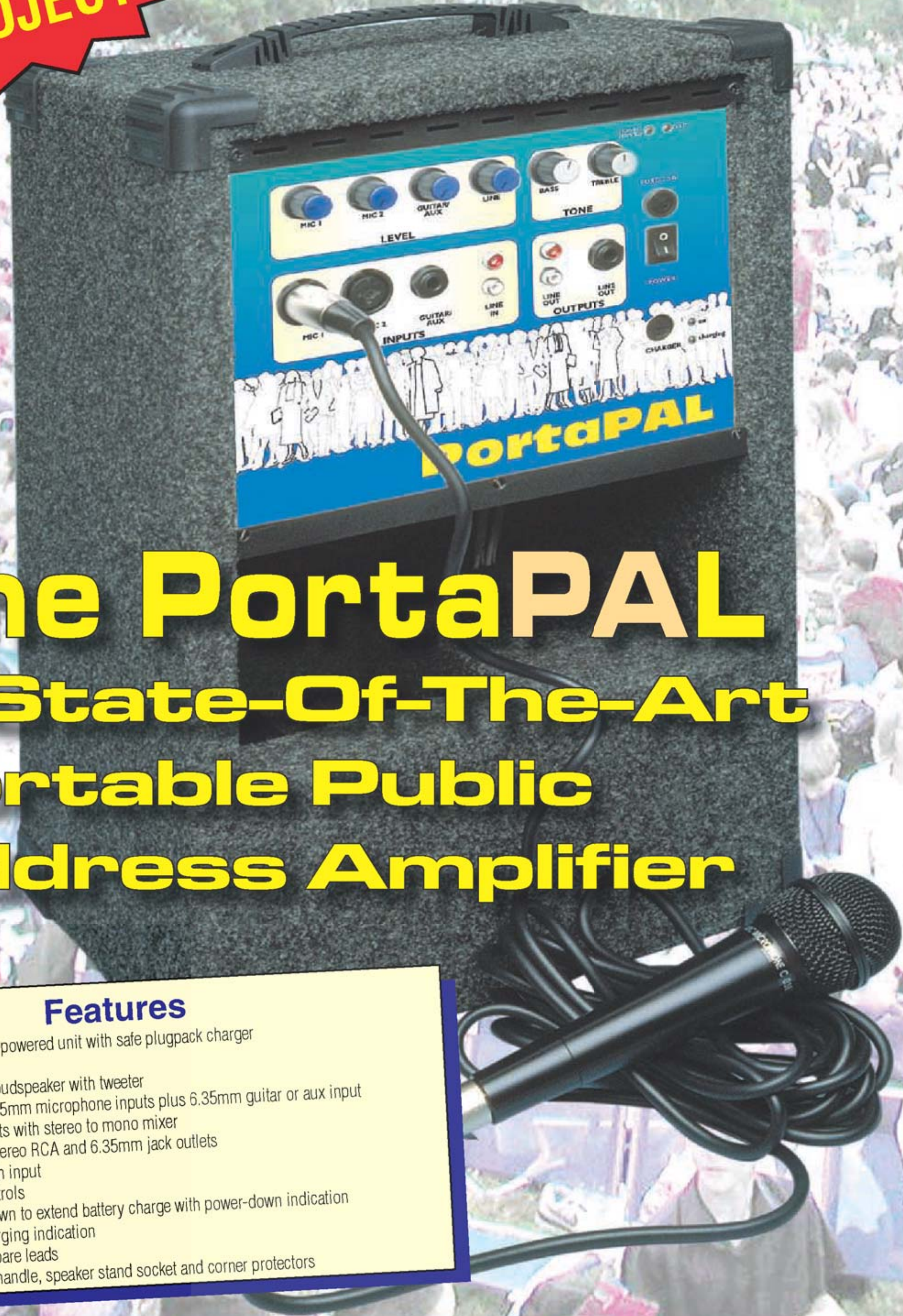
YORKS 100% BROADBAND!

Every telephone exchange in the Yorkshire and the Humber region has now been enabled for broadband making it one of just three UK regions to have achieved 100% enablement. The final exchange – at Ramsgill Dale in North Yorkshire – was enabled for broadband at the end of December.

Working with BT and Adit, the regional procurement agency, Yorkshire Forward last year agreed to provide funding to make broadband available in the 24 exchanges that BT had previously announced were not commercially viable under its national broadband roll-out programme.

Yorkshire Forward has also liaised closely with the community groups that have already established networks in these locations, using alternative technologies.

FEATURE PROJECT



The PortaPAL

A State-Of-The-Art Portable Public Address Amplifier

Features

- Portable, 12V battery-powered unit with safe plugpack charger
- High power output
- Inbuilt 200mm (8") loudspeaker with tweeter
- 2 combined XLR/ 6.35mm microphone inputs plus 6.35mm guitar or aux input
- Stereo RCA line inputs with stereo to mono mixer
- 2 line outputs with stereo RCA and 6.35mm jack outlets
- Level control for each input
- Bass and Treble controls
- Automatic power-down to extend battery charge with power-down indication
- Charger on and charging indication
- Storage space for spare leads
- Box includes carry handle, speaker stand socket and corner protectors

Part 1: by JOHN CLARKE & LEO SIMPSON

THIS PORTABLE PA Amplifier can be powered from the 240V AC mains or its inbuilt 12V sealed lead-acid (SLA) battery. It delivers up to 70 watts and pulls a number of tricks to keep battery current low while still maintaining very high performance.

The design is based around the Philips TDA1562Q power IC. This ground-breaking IC uses special techniques to deliver up to 70 watts from a 12V battery and does away with the need for a DC-DC inverter.

The PortaPAL is a complete system, including mixing for two 600Ω balanced or unbalanced microphones, guitar input and line inputs for a CD player or a cassette deck.

This circuit makes use of the TDA1562Q's muting feature, to further reduce battery drain and keep hum and noise very low.

We've also taken advantage of the inbuilt 12V SLA (sealed lead-acid) battery to eliminate a heavy transformer and large and expensive electrolytic filter capacitors from the power supply – leading to a considerable cost saving.

No DC-DC inverter needed

Up until the release of the Philips TDA1562Q IC, if you wanted more than about 16 watts from a 12V-powered PA system, you had to resort to a DC-DC inverter to provide power supply rails of, say, ±40V, to get around 50 watts into an 8-ohm load.

Not only are DC-DC inverters relatively complex but even the most efficient designs inevitably lead to a reduction in overall circuit efficiency.

With its special class-H operation and bridged amplifier operation, the TDA1562Q not only eliminates the need for an inverter but its class-H operation is considerably more efficient than a normal class-B amplifier which is what would be normally used.

So enough of the rave about the TDA1562Q. Now let us have a look at the other features of this great little (actually, not so little) portable PA Amplifier.

Features

Housed in a timber cabinet measuring 450 x 280 x 240mm, the PortaPAL amplifier uses a 200mm 4Ω speaker. The speaker is specified as a 4Ω model because the amplifier is designed to deliver maximum power into a 4Ω load.

All the controls are at the rear of the cabinet. There are two XLR sockets for connection of low impedance (600Ω) balanced microphones. These special XLR sockets also accept standard 6·5mm jack sockets so that unbalanced microphones can be used as well.

There is also a pair of RCA phono sockets for connection of a CD player or cassette deck and RCA sockets are also provided for line out signals to a cassette deck, if the proceedings need to be recorded, or to another PA system. This output is also duplicated at a 6·35mm stereo jack socket.

There are four mixing knobs for the microphones, guitar and line inputs but there is no master level control, to keep things simple. Bass and Treble tone controls are provided and automatic VOX is built in.

There are four LEDs on the panel, two at the top righthand corner and two lower down, adjacent to the plugpack charger input socket. At the top, one of the LEDs flashes about twice a second to indicate that the unit is on while the other is the "Fault" indicator. We'll talk more about this and the charger LEDs later.

The only other control is the On/Off switch. Also on the rear panel is the lid for the 12V battery compartment and the battery can be quickly changed over if that is necessary. Power comes

PortaPAL Specifications

Output Power	33W RMS into 4Ω (depending on battery voltage)	
Music Power	70W RMS into 4Ω (depending on battery voltage)	
Frequency Response	Line	-3dB at 26Hz and 40kHz
	Guitar and microphone	-3dB at 42Hz and 20kHz
Tone Controls (see graphs)	+13dB and -14dB at 100Hz	
	+11dB and -13dB at 10kHz	
Input Sensitivity: (for 30W into 4Ω)	Line	340mV RMS
	Guitar	16mV RMS (1.9V RMS overload)
	Microphone	1·3mV RMS (130mV RMS overload)
Signal-to-Noise Ratio: (all figures with respect to 33W)	-83dB unweighted (20Hz to 20kHz); input level controls all off	
	-71dB unweighted with microphone level set at maximum sensitivity (-73dB A-weighted)	
Muting	Threshold:	<7mW output power
	Time:	15 seconds (typical) after signal drops below threshold
		100ms (typical) unmute when signal applied
Battery Consumption	Standby (mute)	26mA
	No signal (unmute)	160mA
Battery Charger	Charge rate:	1A maximum
	Charge voltage:	13·8V maximum
Dimensions:	500 x 295 x 250mm (including handle and corners/feet)	
Mass	13kg (including charger plugpack)	

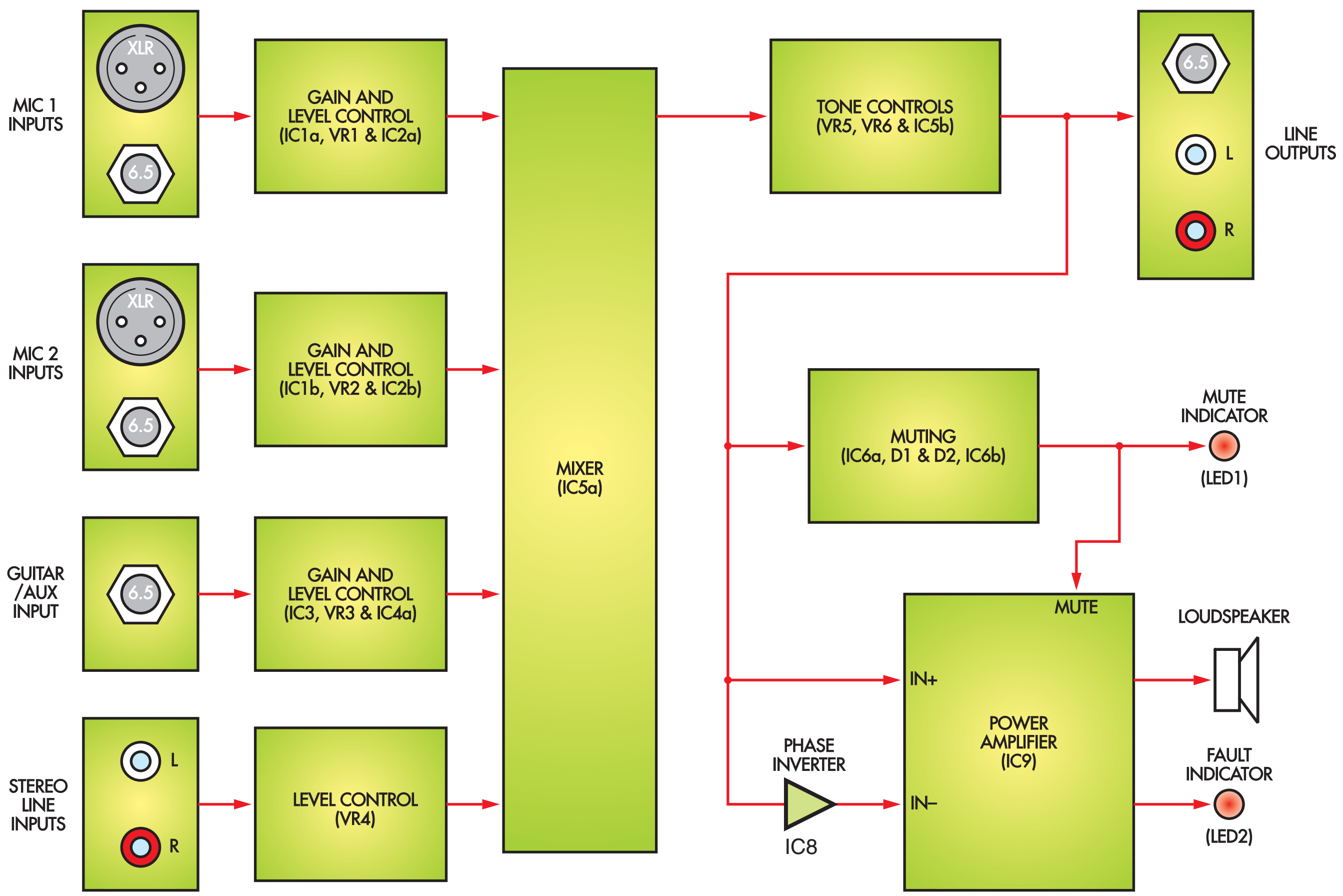


Fig.1: all of the functional areas of the PortaPAL are shown in this block diagram, with the exception of the mains power supply/SLA battery charger.

from the battery or an external 16V AC 1·5A plugpack.

While the plugpack has relatively low power rating (24VA) with respect to the maximum output of the PA amplifier, it is quite adequate to keep the battery fully charged in normal PA operation. In fact, the power supply is really just a battery charger with the battery permanently connected.

The inbuilt VOX operates to mute the power amplifier if there is no signal for more than 15 seconds, reducing the standby battery consumption from 160mA to around 26mA.

While it is hard to be precise, we estimate that the inbuilt 12V 7Ah battery should be good for about five to six hours use. In practice, that means you could typically use the PortaPAL all day on battery power.

Circuit overview

Fig.1 shows the simplified block diagram. Apart from the TDA1562Q power amplifier IC, there are eight low-cost ICs and not a lot else. The microphone input signals are amplified in op amps IC1a and IC1b, while the guitar signal is amplified by op amp IC3.

The microphone, guitar and line signal levels are set by VR1, VR2, VR3 & VR4 and then mixed and fed to the tone control stages and to the muting circuit involving IC6, D1 & D2. This circuit provides a mute signal to the power amplifier when the audio signal levels are below a certain threshold.

Circuit details

As already noted, the Portable PA uses two special XLR sockets which also accept stereo or mono 6·5mm jacks. For simplicity, these sockets are shown on the circuit of Fig.2 as separate XLR and jack sockets but remember that they are combined into what look like ordinary 3-pin XLR sockets.

In normal operation, using a microphone with an XLR plug, the balanced microphone signals are fed to the inputs of op amps IC1a & IC1b. These provide a gain of 22 from a 600Ω microphone.

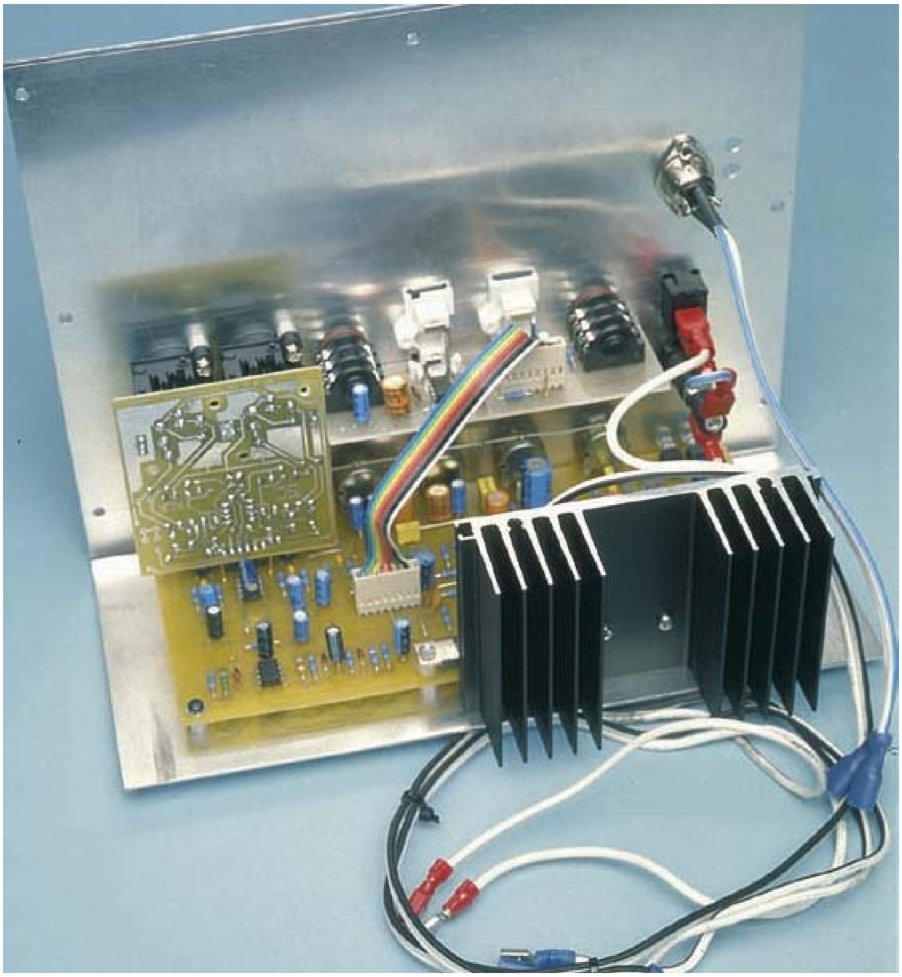
Both microphone preamps are identical except that the MIC1 preamp has provision for a bias voltage (phantom power) for electret microphones, if required.

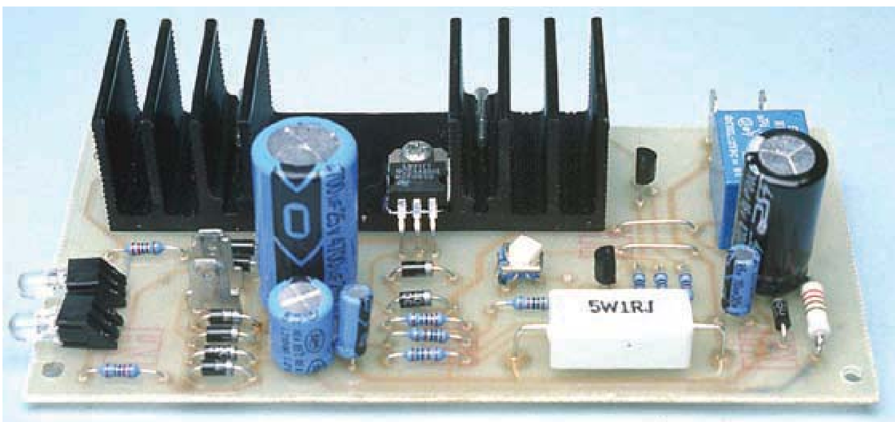
The use of 1% resistors in the balanced microphone circuits ensures good rejection of common mode signals such as hum and hash.

High frequencies above 50kHz are rolled off by the 150pF capacitors across the 22kΩ feedback resistors. The 390pF capacitors shunting the balanced input lines, in conjunction with the microphone impedance, also roll off the high frequencies.

Should you insert a 6·5mm stereo jack plug from a balanced mike into the XLR socket it will again be accepted as a balanced signal and converted to a single-ended output.

But here is the clever part. We have wired it so that if you insert a mono jack into the socket, the non-inverting input (pin 3 of the XLR) is grounded





Construction will be fully described next month but to whet your appetites, at top we show the completed amplifier assembly ready for mounting in the box, while immediately above is the separate SLA charger board. By the way, this could be built independently as a high performance SLA battery charger.

and IC1a (or IC1b) operates as a normal non-inverting amplifier with a gain of 22.

Thus we cater for both balanced and unbalanced low impedance microphones.

The unbalanced outputs of op amps IC1a & IC1b are each fed to level potentiometers VR1 & VR2 via a 150Ω resistor and 1µF capacitor. The signals from VR1 and VR2 are then applied to op amps IC2a and IC2b, both of which have a gain of 11. This means that maximum gain for microphone signals is 242.

Guitar input

The guitar input stage involving the TL071 Fet-input op amp IC3 looks like a straightforward non-inverting amplifier but there are a number of interesting wrinkles.

First, the guitar signal is coupled in via a relatively large value of capacitor, 47µF, especially when the input load resistor is also high at 470kΩ. This is because we are aiming for two separate outcomes. We have specified the high load resistance of 470kΩ to ensure optimum high frequency response with the relatively high inductance of typical guitar pickups.

With such a high load resistance, you might wonder why we have used such a large input coupling capacitor. After all, to maintain a flat response to below 20Hz, all you need is a 15nF (0·15µF) input capacitor. Why use 47µF, 300 times bigger?

The answer is that the inductive guitar pickup represents a low source resistance at low frequencies. In order to minimise noise, op amp IC3 needs to see as low a source resistance as possible. Ergo, we use a big capacitor.

IC3 is set for a gain of just two. This is adequate for any guitar (when the following gain is accounted for) but it also means that this input can handle line input signals of up to 1·9V before overload occurs.

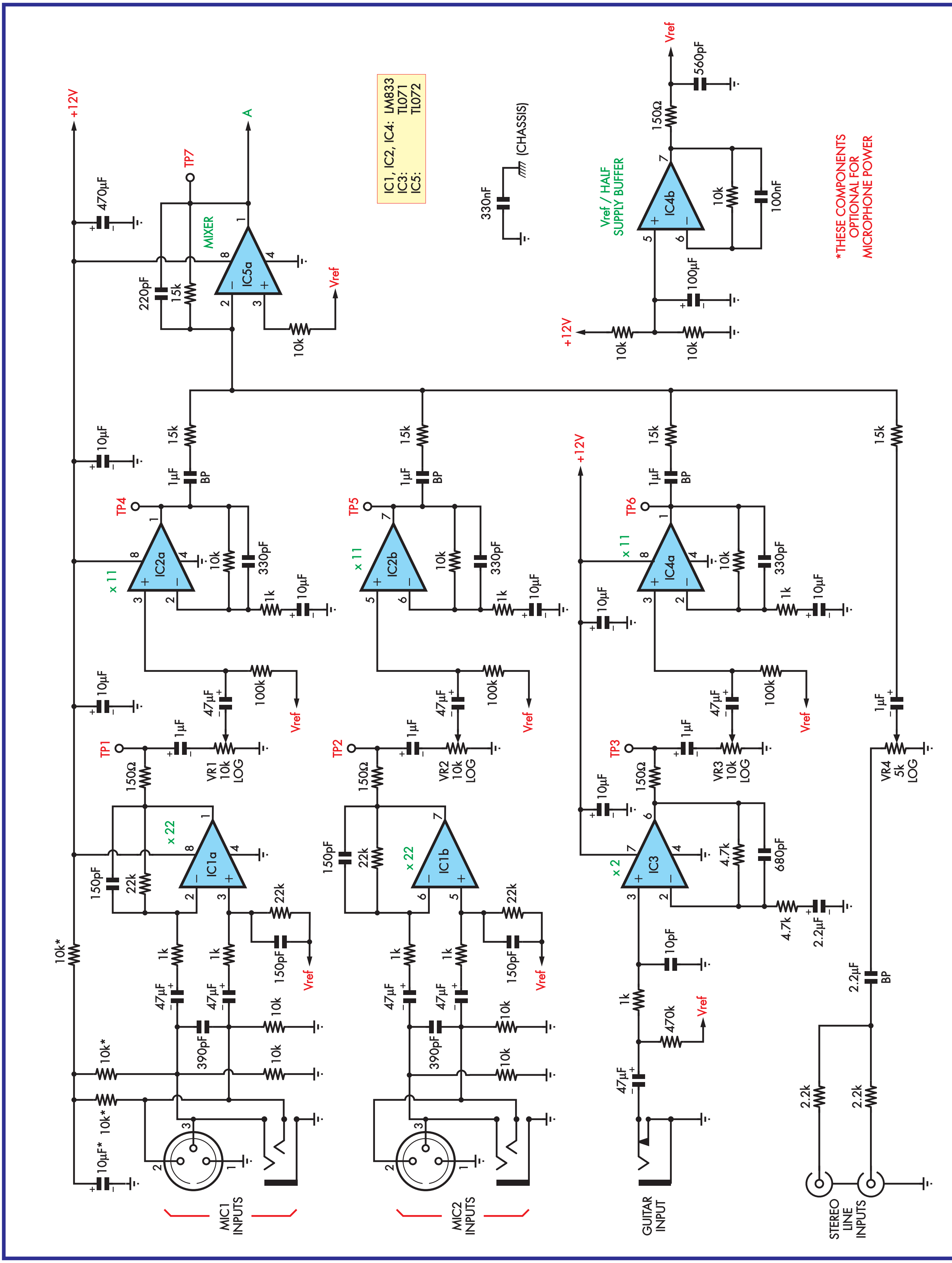
Following potentiometer VR3, the guitar signal is fed to op amp IC4a, which has identical gain to IC2a & IC2b.

Stereo line inputs (eg, from a CD player) are mixed to a mono signal with 2·2kΩ resistors and fed to potentiometer VR4. All of the signals from the four potentiometers are then mixed in IC5a which has gain of unity. Note that the input resistor from VR4 is 10kΩ rather than 15kΩ to make up for a slight gain loss in the resistive mixing of the stereo line inputs.

IC5a drives the tone control stage involving IC5b and this has its output signal fed to three places: the line output to RCA and 6·35mm jack sockets; the muting stages involving IC6 and the power amplifier involving IC8 and IC9.

All of the op amps in the circuit, with the exception of IC4b and IC6, have their non-inverting (+) inputs biased from the V_{ref} line which is at +6V.

This is derived from the +12V line by a voltage divider consisting of two 10kΩ resistors with the centre point bypassed by a 100µF capacitor. The



IC1, IC2, IC4: LM833
IC3: TL071
IC5: TL072
MIXER
IC5a
IC1a
IC1b
IC2a
IC2b
IC3
IC4a
IC4b
Vref / HALF SUPPLY BUFFER
*THESE COMPONENTS OPTIONAL FOR MICROPHONE POWER
(CHASSIS)
330nF
+12V
Vref
A
TP1
TP2
TP3
TP4
TP5
TP6
TP7
x 22
x 11
x 2
VR1 10k LOG
VR2 10k LOG
VR3 10k LOG
VR4 5k LOG
MIC1 INPUTS
MIC2 INPUTS
GUITAR INPUT
STEREO LINE INPUTS

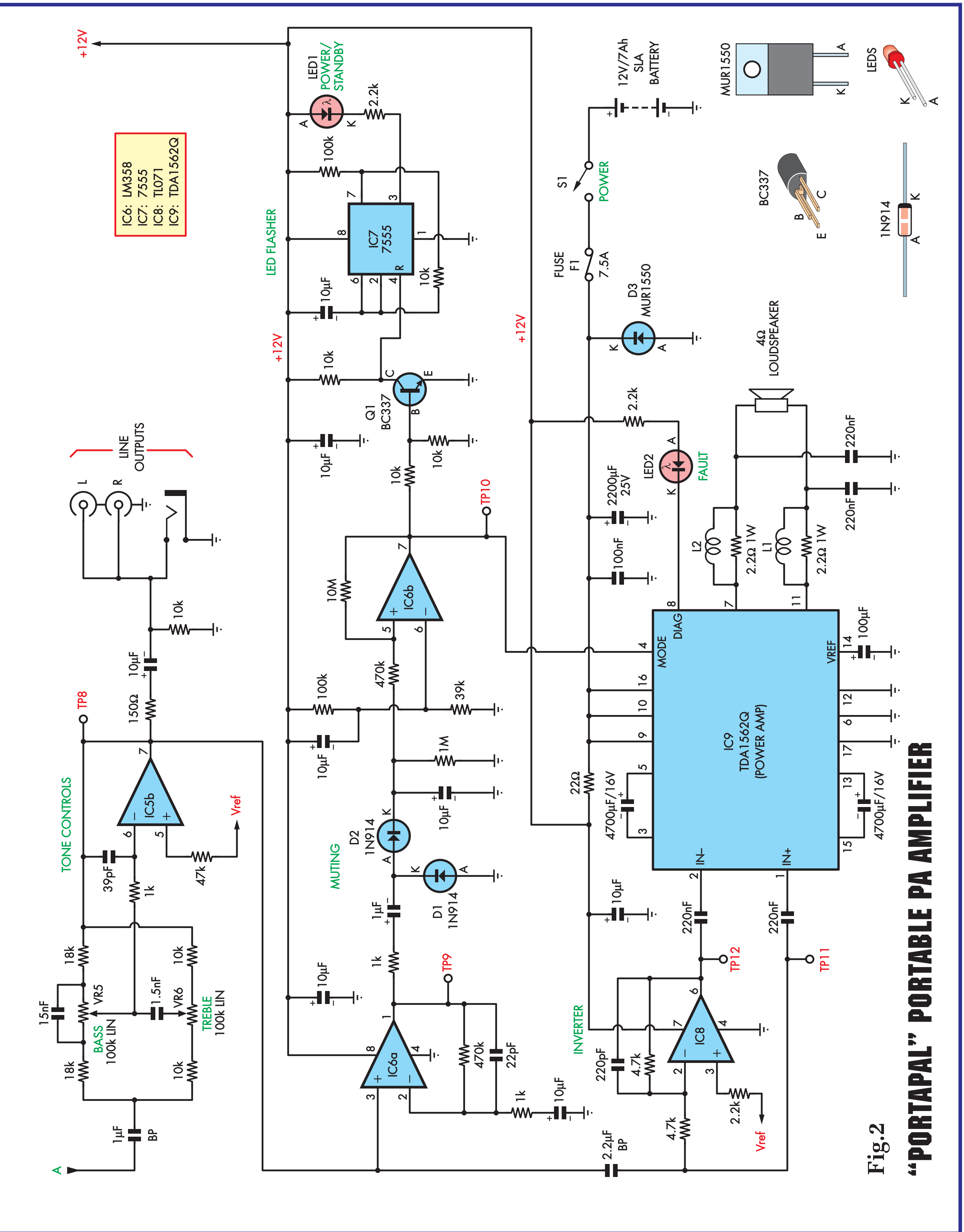


Fig.2 "PORTAPAL" PORTABLE PA AMPLIFIER

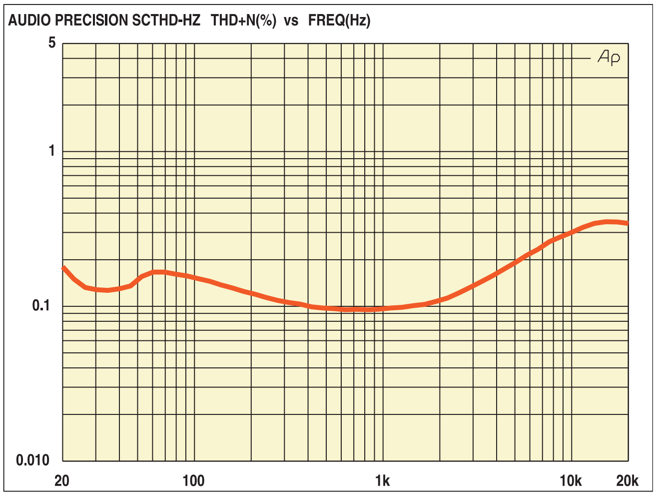


Fig.3: total harmonic distortion versus frequency at 12W using the microphone input.

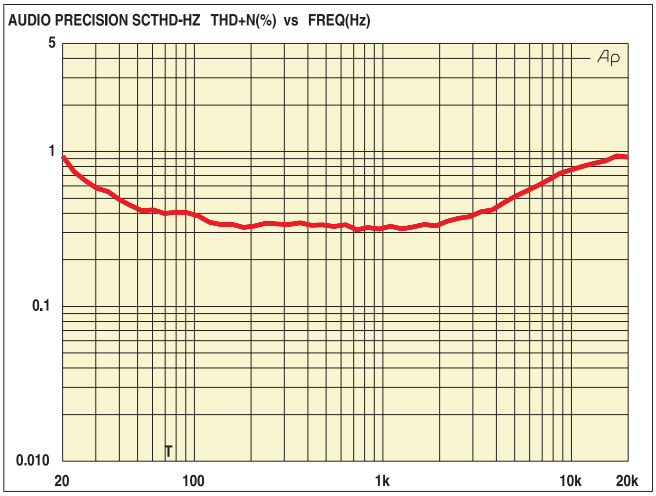


Fig.4: total harmonic distortion versus frequency at 30W using the microphone input.

bypassed supply is then buffered by op amp IC4a to provide the V_{ref} line.

This means that all op amps will have symmetrical clipping at overload, to maximise the output signal. All op amp outputs, with the exception of IC6b, will sit at +6V (or half the battery voltage).

Muting stages

As noted above, we have incorporated VOX into the circuit to mute the amplifier and cut current consumption when no signal is present. This muting function is provided by dual op amp IC6. Op amp IC6a is a non-inverting stage with a gain of 471 by virtue of the 470kΩ and 1kΩ feedback resistors. The 22pF capacitor rolls the gain off above 15kHz, while the 10µF capacitor in series with the 1kΩ resistor rolls off signals below 16Hz.

The amplified signal from IC6a is then fed to a diode pump circuit consisting of diodes D1 & D2 and 1µF & 10µF capacitors. Hence, the peak level of the signal from IC6a will be stored in the 10µF capacitor which is continuously being discharged via the 1MΩ resistor across it.

The 10µF capacitor is monitored by IC6b which is connected as a Schmitt trigger. A 10MΩ resistor between pin 5 and pin 7 applies a degree of positive feedback to give hysteresis. This makes the comparator output switch cleanly between high and low, to prevent the possibility of parasitic oscillation at the switching points.

The inverting input of IC6b is set at +3·4V using the 100kΩ and 39kΩ resistors across the 12V supply.

When power is first applied to the circuit, the 10µF capacitor between the 12V supply and the inverting input to IC6b is initially discharged and therefore pulls pin 6 high, causing pin 7 to be low.

Pin 7 of IC6b is connected to the mute (mode) input, pin 4, of the power amplifier, IC9. So at power-up, the amplifier is muted.

Once the audio signal monitored by IC6a is of sufficient level, IC6b's output will go high and the power amplifier will be unmuted.

Muting indication is provided by IC7, a CMOS 7555 timer, which drives LED1, the power/standby indicator. Initially when power is switched on, transistor Q1 is off and so pin 4 of IC7 is pulled high via the 10kΩ resistor connecting to the 12V supply. This allows the 555 timer to run and it flashes LED1 on and off.

The rate of flashing is set by the 10µF capacitor connected to pins 2 & 6 and the associated 100kΩ and 10kΩ resistors.

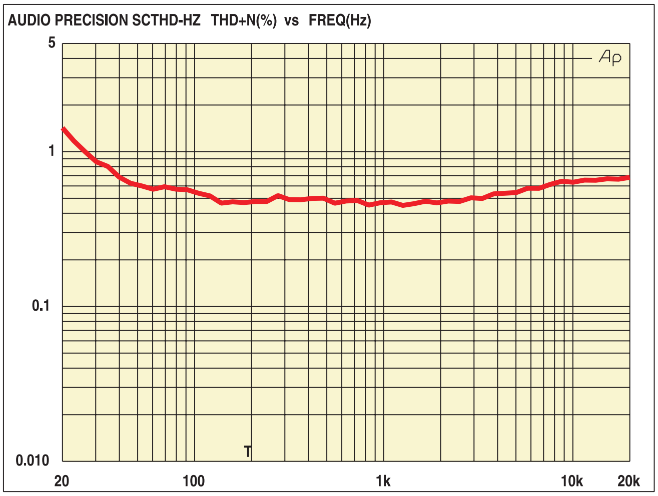


Fig.5: distortion versus frequency at 30W but using the line input.

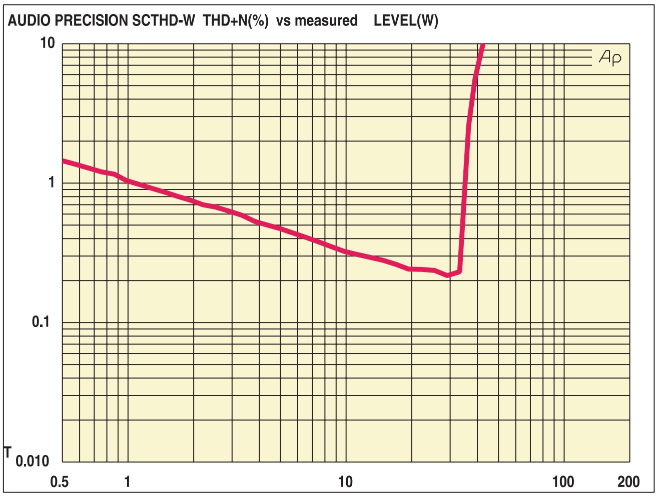
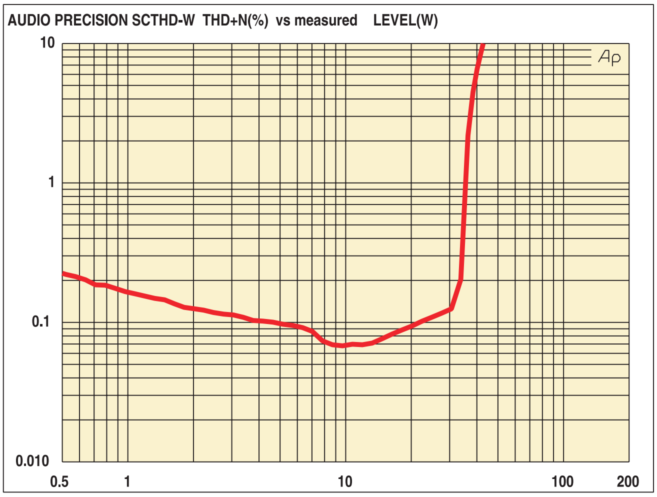


Fig.6: power versus distortion when driven by the mic input. Maximum power here is 42W at 10% distortion.



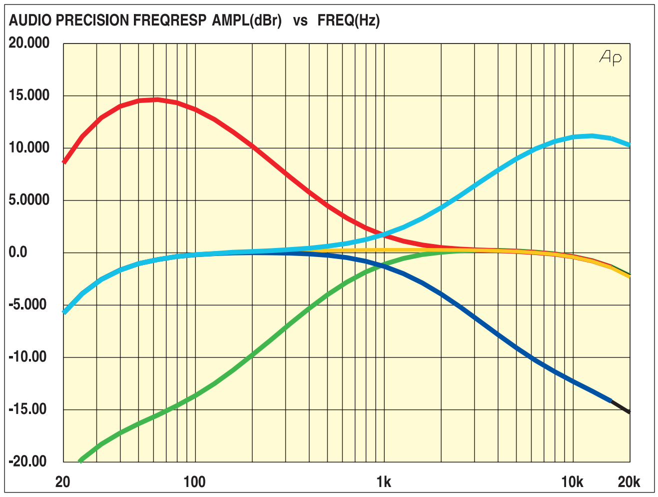


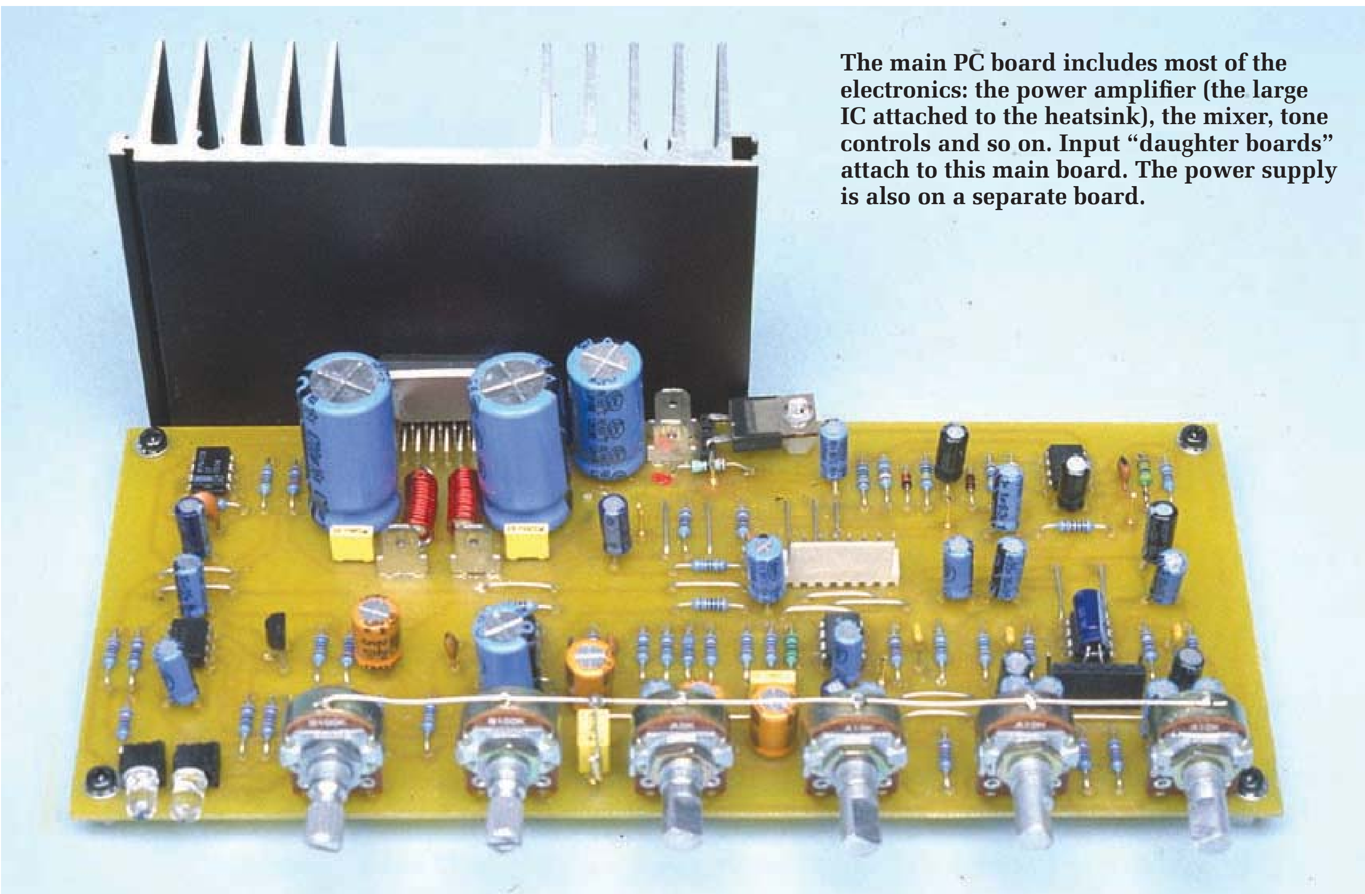
Fig.7: power versus distortion when driven by the line input. The distortion is lower than Fig.6 because of the lower gain from the line input.

Fig.8: the tone control action in the "flat", "max boost" and "max cut" settings.

Note that the 10μF capacitor is tied to the +12V supply rather than 0V, as in a normal 7555 timer setup. The reason for doing this is so that pin 3 of the 7555 will be low when power is first applied and the LED will light immediately and then flash. If the capacitor was connected to 0V (as in a conventional 7555 circuit), the LED would be off for almost one second before flashing on.

In effect, the 10μF capacitor is charged via the 10kΩ and pin 7 and then discharged to +12V via the 10kΩ and 100kΩ resistors. Since the ratio of the charge/discharge resistances is 1:11, the LED flashes with about the same duty cycle (on for 70ms, off for 770ms) and thereby keeps current drain to a minimum when the amplifier is muted; LED1 draws about 400μA.

When pin 7 of IC6b's output goes high to unmute the power amplifier, transistor Q1 is switched on and it pulls pin 4 of IC7 low. This forces the pin 3 output low and LED1 is lit continuously.



The main PC board includes most of the electronics: the power amplifier (the large IC attached to the heatsink), the mixer, tone controls and so on. Input "daughter boards" attach to this main board. The power supply is also on a separate board.

So LED1 is on continuously in normal operation and it flashes when the amplifier is muted.

Power amplifier

IC9 is the TDA1562Q power amplifier which can deliver up to 70W under music power conditions, depending also on the state of battery charge. We are using the mute (pin 4, Mode input) facility, as described above and the diagnostic output at pin 8. This is used to drive LED2. It will show when the amplifier is clipping, if there is a short at the output, if there is an open circuit load and if the amplifier has gone into thermal shutdown.

If you want a full description of the TDA1562Q, you will need to refer to the manufacturer's data sheet. We will briefly the describe the circuit operation here.

The TDA1562Q actually contains two power amplifiers which drive the 4Ω speaker in bridge configuration and its inputs are balanced. So we drive these balanced inputs (pins 1 & 2) with signals that are 180° out of phase.

Hence, pin 1 of IC9 is driven directly from the output of IC5b (albeit via two capacitors) while pin 2 is driven from the output of IC8, a TL071 op amp connected as a unity gain inverter.

The two 4700µF capacitors at pins 3 & 5 and pins 13 & 15 of IC9 are "lift supply" reserves for when momentary high power levels are required.

Both amplifier output terminals pass through Zobel networks, each comprising a 2·2Ω resistor and parallel inductor shunted via a 220nF capacitor. The components are included to guarantee stability (ie, stop any tendency to supersonic oscillation) when driving reactive loads.

Power for the circuit comes from a 12V 7 amp-hour battery which is fed via switch S1 and a 7·5A fuse. Diode D3 is included should the battery be connected the wrong way around. If that happens, the diode will conduct and blow the fuse.

Next month

In the April issue, we will present the charger circuit for the PortaPAL. This can be built as a general-purpose charger, as well as the power supply for this amplifier.

We will also present the full construction details of the PortaPAL PA amplifier. ***EPE***

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BODY CELLS

Fed up with paying an arm and a leg for batteries to go in portable gadgets? Body cells could be the answer, as Mark Nelson explains.

THE smaller the battery, the bigger the price – or so it seems. However handy they are to have, it seems that the Walkmen, BlackBerries, GPS gizmos and other gadgets we rely on seem to be eating us out of house and home in running costs. How much better it would be if we could harness the heat of our own bodies to generate electricity for free!

Unlikely as that may sound, it's already a reality and whilst the price is far from pocket money just now, it's entirely possible that technology transfer and mass production could one day bring the price of body power down to consumer levels.

Electric Personality

One of the reasons why body heat has not been exploited for power to any great degree so far is the limit to the power that can be generated. Even state-of-the-art devices manage only 100 microwatts at 1·5V, even for someone with an utterly electric personality. This means that research effort must be applied to ways of reducing power consumption as well as power generation.

One of the leaders in this field is the Belgian firm IMEC, which focuses its micropower research on medical applications such as monitoring heartbeats, brainwaves and the health of muscles and the nerves that control them. It is already producing third-generation devices for monitoring human health and is also working on even more advanced projects of this kind.

The ultra low-power wireless body area networks (WBANs) that IMEC is developing require patients to wear a combined sensor, microcontroller and radio transmitter (operating on 433MHz or 2·4GHz). About the size of a normal wristwatch, this is worn on the underside of the wrist, directly over an artery.

Because people's temperatures vary over time, the telemetry device cannot rely on a constant power supply and two NiMH cells are used to stabilise the power. Raw power comes from a four-stage thermopile employing several thousand thermocouples, each of which develops approximately 0·2mV per degree centigrade of temperature difference and producing up to 500 microwatts in all. Dependant on converter efficiency, up to 70 per cent of this energy can be used for practical purposes if the thermopile generator is matched with the load.

Mechanical Means

Further improvements to IMEC's thermal generators are expected to investigate thermal modelling of the human body to determine the optimum place and design of the generator and design of power conditioning circuitry. The company is also working on mechanical micropower generators that convert vibrations from movement into electricity electrostatically. A preliminary generator that produces 10 microwatts per cubic centimetre has been developed and current efforts will further improve this device to tune the resonance frequency, increase power output and build in a fixed voltage bias in the design, making an external voltage source obsolete.

Lab-on-a-Chip

Status monitoring is not the only application of body heat generators, however. Thermoelectric power can also be used to power heart pacemakers and other devices, such as the tiny neuro-transmitters that are implanted in the brains of some people with Parkinson's disease. A company active in this field is Biophan Technologies of New York, which is developing a "biothermal battery" that employs body heat for generating electricity.

Unlike the IMEC design, this one is implanted in the body for better heat conduction, meaning its uses are strictly medical unless the government insists on equipping us with RFID identity tags or someone comes up with a thought-controlled radio receiver for the brain! Biophan's approach is developing power systems for pacemakers and lab-on-a-chip devices that will run entirely on body heat emission, which will lengthen the useful life of the implanted devices.

Michael Weiner, the company's chief executive officer, states: "The objective is to extend the time between surgeries that are often performed to replace a battery that has run down – a period of five to seven years for pacemakers, but shorter for implants such as neuro-stimulators and drug pumps. Ideally, we'd like to give the patient a device that potentially never has to be explanted to replace a power source."

Old Technology Revived

The technology being used, he continues, is the Seebeck effect, using semiconductor devices that are not batteries but arrays of tiny elements that convert heat flow directly into electrical current. This mechanism was discovered as far back as 1821 and produces electricity when you join two different metals (or semiconductors) maintained at different temperatures. This is the basis of the thermocouple that was used to power radio receivers in gas-only homes before the war. Weiner concedes that for Biophan there is a challenge to find materials and novel designs that maximize efficiency of power conversion (the temperature gradient between the hot and cold side is pretty small inside the body).

The British Heart Foundation sees considerable potential in this the project to relieve the anxiety for people who rely on pacemakers (more than 26,000 people in the UK had one implanted last year). Quoted in *New Scientist* magazine, Dr Tim Bowker, the Foundation's associate medical director, declared: "We would welcome any advance in technology which could prolong the pacemaker's battery life, and which was safe and acceptable to the patient. If the battery could be replaced less frequently, patients would need fewer surgical procedures, which are both stressful and carry a risk of infection."

Central Heating for Free

Whatever you spend on batteries, you can bet that your household heating costs are far greater, especially when you consider that some 20 per cent of the bills go straight up the chimney – or through poorly insulated walls and lofts and through single-glazed windows. Imagine then a house that has no heating bills at all, or rather don't bother because it's not imagination at all.

This house where no heat is wasted is the Wates House in Mid Wales, built 29 years ago and still the best insulated building in Britain.

Although it's a normal family-type home, what sets it apart is triple glazing and 450mm (18 inches for old fogeys like me) of cavity wall insulation. So efficient is this house that even in the depths of winter the heat from electrical appliances, lamp bulbs and human bodies is enough to avoid the need for additional heating.

If you find this unbelievable, you can see the house for yourself any time after this Easter, when it reopens following refurbishing. It's at the Centre for Alternative Technology, a few miles from Machynlleth and a wonderful place to see ecological ways of generating electricity from wind, water and sunlight power. The site attracts 75,000 visitors a year and as a contribution to environmental transport, visitors enter the site by a cliff railway propelled by water.

CAT makes a superb day out and you can see some of the world's most energy-efficient buildings, including its new £600,000 environmental information centre, which produces more energy than it consumes and achieves energy standards 20 times better than official definitions of best practice. Every exhibit is explained clearly and you can obtain information sheets in the bookshop. There's a superb wholefood restaurant there too!

The contact details are: Centre for Alternative Technology, Machynlleth, Powys, SY20 9AZ, Wales. (01654) 705991. **www.cat.org.uk**.

Telescope Interface

Automate the manual setting of the time, date and global coordinates for your Meade telescope.

By JOHN BECKER

SOME months ago *EPE* reader Jason Kotecki of Grand Rapids, Michigan, USA emailed the author asking:

"How easy would it be to have your *GPS To PIC and PC Interface* of Jan '04 send out GPS serial data to a Meade telescope LX200 I have, to set the latitude, longitude and time values that it needs? At present these have to be set manually each time the telescope is switched on."

Although Meade have their own separate GPS interface available for this electronically controlled telescope, Jason's requirements were for his existing GPS handset to be used with his telescope. The GPS would be interfaced to a PIC, which would extract from the GPS signal the following data, local to where the telescope was positioned:

- Current time in UTC (Universal Time Coordinate), effectively the same as GMT (Greenwich Meridian Time)
- Calendar data
- Latitude and Longitude

The PIC would then convert the GPS data to Meade protocol codes and output them to the telescope.

Chatting with Editor Mike, we agreed that this would be a project suitable to *EPE*. So the author entered into detailed discussions with Jason by email, and in due course sent him a p.c.b. so that two units were under development and test across "the pond".

Heavenly Viewing

For the uninitiated reader who is reading this only for interest, it is worth pointing out that an astronomer's view of the heavens depends on where the telescope is positioned on the earth's surface and the angle at which it is pointing, vertically and horizontally. As the earth rotates, the telescope's angular view also changes, and the telescope must be told where to point in order to view a particular stellar region.

In order to do this, the telescope's controls must know the latitude and longitude of its position, and the local time of day there in relation to the international standard time at the Greenwich meridian, London, UK.

Once the telescope knows its position and local time factors, it can be told to automatically point to any required stellar zone with considerable accuracy. Normally the Meade LX200 has to be manually set with its location and current time on each occasion that it is switched on.

A suitably interfaced GPS (Global Positioning Satellite) navigation receiver can provide most of the positioning and time data needed to replace the manual setting. The remaining data is set into the PIC either manually or by a PC. It remains there indefinitely, even after the PIC is switched off, and is available to be output automatically to the telescope when required.

Interface Line-Up

The unit described here allows the telescope's manual setting to be automated

and can be assembled and used in three versions:

Basic Unit: Interfaces between GPS and telescope (does not need PC)

GPS-less Unit: The PIC has a real time clock chip (RTC) connected. The latter is kept powered by a longlife (10 years) battery and keeps time updated even when the main power is switched off. The pair have initial data loaded into them by a PC. The unit then becomes standalone, outputting data to the telescope when required.

Full Unit: Comprises both the above versions.

Table 1: Example coding for an NMEA 0183 $GPRMC sentence

$GPRMC,102618,A,5048.349,N,00154.706,W,000.0,315.2,062905,003.8,W*7A
0 1 2 3 4 5 6 7 8 9 10 11 12

Field	Data	Description	Meaning
0	$GPRMC	sentence identifier	Information type
1	102618	time of fix	10:26:18 UTC
2	A	validity	OK (A = OK, V = invalid)
3	5048.349	current latitude	50°48.349
4	N	North/South	North
5	00154.706	current longitude	001°54.706
6	W	West/East	West
7	000.0	speed in knots	0.0 knots
8	315.2	true course	315.2°
9	062905	date stamp	29 June 2005
10	003.8	magnetic variation	3.8°
11	W	West/East	West
12	*7A	checksum	7A (in hex)

The location which this represents is *EPE* HQ.

GPS to Meade Conversion

As explained in the GPS article of Jan '04, GPS handsets typically output several sentences of positional and related data in several sentences, each prefixed by an ID code. The one appropriate to the Meade has a prefix ID of $GPRMC and is structured according to the NMEA 0183 standard (NMEA stands for National Marine Electronics Association). An example is shown in Table 1.

The fields which the telescope needs to know are 1, 3, 4, 5, 6 and 9, but they first need to be converted to the Meade protocol.

Field 1, time, needs to be converted from UTC to local time, but only the hours and minutes are used. Local time in respect of UTC depends on two factors:

- The number of hours difference between the Greenwich meridian and the time zone in which the telescope is positioned. This is known as the UTC Offset. The value is positive for locations east of Greenwich, and negative for locations west of Greenwich.
- Whether or not Daylight Saving Time applies (DST) – as for example whether the UK is currently in BST (British Summer Time) or GMT (Greenwich Meridian Time)

UTC Offset and DST values are not supplied by the GPS, but are entered by the user.

In the case of the example sentence, the UTC offset is zero as the local time zone is in the UK. and the DST Value is 1 (BST applies). DST would be 0 if GMT applied. Local time is therefore:

10:26:18 UTC + 0 (Offset) + 1 (DST) = 11:26:18

If the UTC had been in relation to Jason's locality, Grand Canyon, the UTC Offset would be –5 hours and his equivalent local time would be 06:26.11 (DST applying).

Only the local hours and minutes are sent to the telescope, with seconds ignored.

Fields 3 and 4, latitude. Only the degrees and whole minutes of the latitude are used, in this case 50°48′, but they need to be related to the hemisphere in Field 4 (N/S). Northern latitude is considered positive, and southern is negative.

Fields 5 and 6, longitude. Again only the degrees and whole minutes of the longitude are used, in this case 01°54′, and now related to the W/E position given in Field 6 and in respect of 360°. Westerly values remain unchanged, but easterly values are deducted from 360°. Thus, if the longitude were to be 01°54 east, the angular position would be expressed as 358°06′.

Field 9, date. Normally all three date values apply as received, but a complication arises if the difference in UTC and local time results in a date change, as in the case of 01:00:00 UTC on 28 June 05. In this case Jason's local time and date would be 21:00:00 on the 27 June 05.

The conversion from one date to another also requires that both the month and year may need to be changed in the case of UTC and local time being in different date zones. In this case the number of days in a given month must be taken into account, and also a leap year in relation to February. It is not particularly complicated, but it does require a fair amount of PIC code.

Having extracted and converted the field data, it is then formatted to the Meade's own code. The equivalent for the example GPS sentence is given in Table 2.

Table 2: Example Meade code format

Subject	GPS	Meade Format	Meade Code
Local Time	10:26:18	HH:MM:SS	:SL 10:26:18#
Local Date	06:29:05	MM:DD:YY	:SC 06:29:05#
Latitude	50°48.349'N	sDD:MM	:St +50:48#
Longitude	001°54.706'W	DDD:MM	:Sg 001:54#
UTC Offset - (DST applies)		sHH	:SG +01#

Circuit Diagram

The complete circuit diagram for the Telescope Interface is shown in Fig.1. In this application, the PIC16F876 is used as the microcontroller, IC2. It is run at 3·2768MHz, as set by crystal X1. Via Port B, it controls the 2-line 16-characters per line alphanumeric l.c.d. module, X2, which is operated in standard 4-bit mode. It is connected via the terminal pins notated as TB1. Preset VR1 adjusts the l.c.d.'s screen contrast. An l.c.d. with l.e.d. backlighting can be used if preferred – see below.

PIC interfacing to the PC is via an RS232 serial converter IC3 and socket SK1. Data to the telescope is sent via socket SK3 (select the type suitable to the cable used – Meade's own cable details are shown in Fig.3). Communication with the PC is bidirectional, whereas data is only output to the telescope, not received from it.

Data routing from the GPS handset or PC is selected by switch S2a. The GPS handset data is inverted by Schmitt inverter IC5a prior to being fed to IC2. PIC pins RC6 and RC7 are those dedicated by the PIC for serial communication according to RS232 protocol.

Real Time

The real time clock chip (RTC) is IC4. Once it has been programmed with date and calendar data originating from the PC, it keeps it updated for as long its 3V Lithium backup battery B2 remains charged – about 10 years in normal service. Crystal X3 controls the RTC's clock at 32·768kHz. The best accuracy is provided by a clock crystal specified as a 72pF device.

The RTC's current time and date information can be read whenever needed. It is accessed by PIC lines RC3 and RC4, which are allocated for I^2C protocol communications such as this. Resistors R2 and R3 bias these lines normally high.

Pushswitches S3 and S4 have several functions which will be described later. Switch S2b informs the PIC which mode has been selected by S2a. All three switches are biased normally high, S2b and S3 by the PIC's Port B internal pull-ups, and S4 by resistor R4.

LCD Backlight

Provision has been made for an l.c.d. with a backlight to be controlled by the PIC via pin RA2. It is suggested that an l.c.d. with red l.e.d. back-lighting is chosen, so assisting night-time vision when using the telescope.

The backlight is automatically controlled. When the unit is first switched on, the backlight is turned on for 20 seconds, and then goes off. If either switch S3 or S4 is pressed the backlight again comes on, stays on while the switch is pressed, and then goes off 10 seconds after it is released. It also comes on if the GPS signal is not received, going off again when the signal has been regained.

When the PIC takes pin RA2 high, it turns on transistor TR1 via buffer resistor R6. This connects the backlight l.e.d. cathode (k) to the 0V line, allowing current to flow through ballast resistor R6, TR1, and the l.e.d. anodes (a), turning them on. The intensity of the backlighting can be lowered by reducing the value of resistor R5.

An *npn* transistor other than the BC549 shown may be used, providing it can switch at least 100mA of current.

Note that the backlight turn-off timing is linked to the RTC and will not time-out if the RTC has not been initialised.

Power Switch

Power to the full unit is provided by a 9V battery, B1 (e.g. a PP3 type), with S1 as the On/Off switch. The voltage is regulated down to 5V by voltage regulator IC1 to suit the rest of the circuit. When power is on, the RTC (IC4) uses the 5V line rather than its 3V backup battery B2.

The four terminal pins notated as TB2 allowed the PIC to be programmed in situ by the author during development. Diode D1 and resistor R1 prevent the 5V supply line from being adversely affected by PIC programming voltages.

Construction

The printed circuit board component layout and tracking details for the Telescope Interface are shown in Fig.2. This board is available from the *EPE PCB Service*, code 559.

Parts List – Telescope Interface

1 PC board, code 559, 98 x 58mm available from the *EPE PCB Service*
1 plastic case, 150 x 80 x 50mm approx.
1 s.p.s.t. min. toggle switch
1 d.p.d.t. toggle switch (S2 – see text)
2 min. pushswitches push-to-make
1 9-pin serial connector, female (see text)
1 9-pin serial connector, male (see text)
1 socket to suit GPS handset cable connector
1 8-pin d.i.l. socket
1 14-pin d.i.l. socket
1 16-pin d.i.l. socket
1 28-pin d.i.l. socket
1 9V PP3-type battery, with clips
1 3V Lithium battery (see text)
connecting wire, link wire; 4 self-adhesive pcb stand-offs; solder etc.

Semiconductors
1 PIC16F876 microcontroller, preprogrammed (software, including source code, is available from the downloads section of our website at **www.epemag.co.uk**) – preprogrammed PICs are obtainable from Magenta Electronics
1 MAX232 RS232 serial interface (see text)
1 DS1307 real time clock (see text)
1 74HC04 hex Schmitt inverter (see text)
1 78L05 +5V 100mA voltage regulator
1 BC549 *npn* transistor, or similar (minimum 100mA)
1 1N4148 signal diode
1 2-line 16-character (per line) alphanumeric l.c.d., with red l.e.d. back-lighting (see text)
1 3·2768MHz crystal
1 32·768kHz clock cyrstal, 72pF

Capacitors
5 1μ radial elect. 10V (see text)
2 100n ceramic disc, 0·5mm pitch
2 10p ceramic disc, 0·5mm pitch

Resistors (0·25W 5% except where indicated)
3 10k (see text)
2 1k
1 47Ω 0·5W

Potentiometers
1 min. round carbon preset

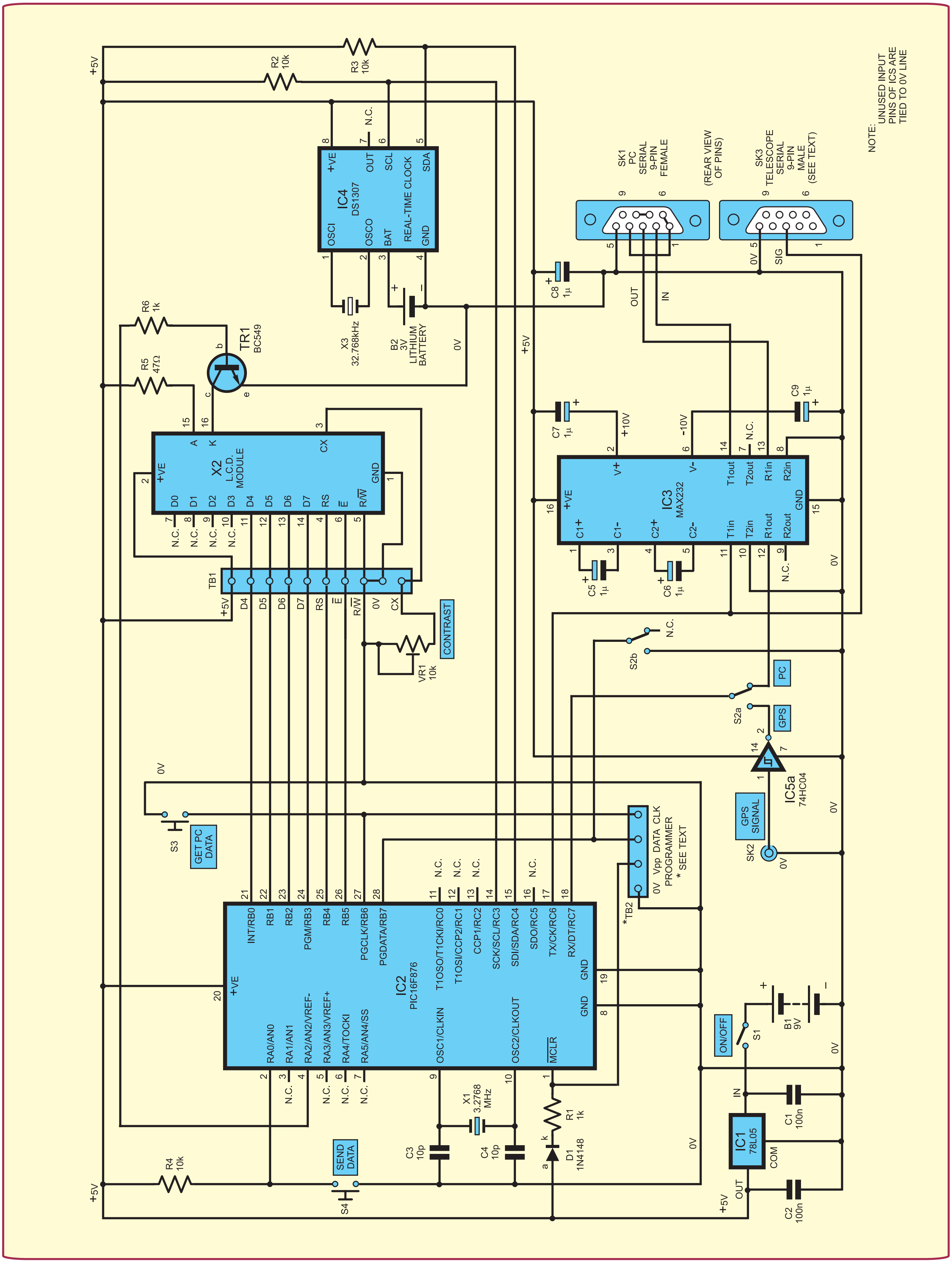


Fig.1. Complete circuit diagram for the Telescope Interface. Note: The unused input pins of IC5 are taken to the 0V line

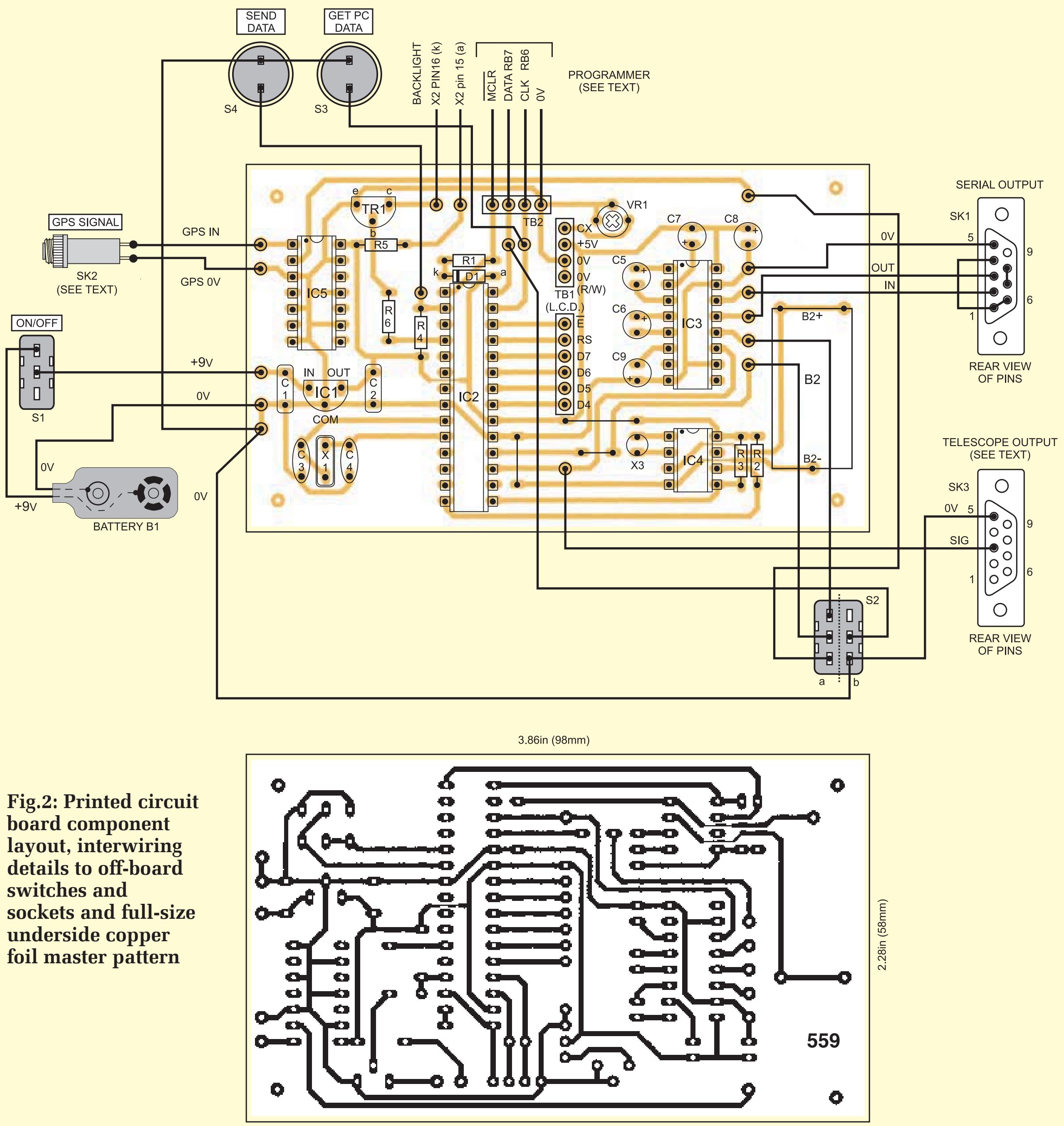


Fig.2: Printed circuit board component layout, interwiring details to off-board switches and sockets and full-size underside copper foil master pattern

If you wish to use the Basic unit only (with GPS, but without PC), omit RTC IC4, resistors R2 and R3, Lithium battery B2, crystal X3, socket SK1, RS232 chip IC3, capacitors C5 to C9 and switch S2. Link IC2 pin 28 (RC7) to IC5 pin 2. Leave RB7 unconnected (it is biased high internally).

For use without a GPS unit, but with a PC, omit IC5, omit switch S2a but retain switch S2b (use an s.p.s.t. switch). Link IC2 pin 18 (RC7) to IC3 pin 12.

Assemble the circuit board in the usual order of ascending component size, on-board link wires first. Use sockets for the d.i.l. (dual-in-line) i.c.s but do not insert these i.c.s or connect the l.c.d. until the board has been fully checked and the output voltage from regulator IC1 proved to be at +5V, within a few millivolts.

When soldering the Lithium 3V battery (B2) to the p.c.b., take special care not to short its terminals.

Boxing-Up

The prototype was housed in a plastic case measuring 150mm x 80mm x 50mm. A slot for the l.c.d. screen needs to be cut in the case's lid, using the traditional technique of drilling a perimeter of holes, and then cutting between them and filing smooth the rough edges. The author used double-sided adhesive foam strip (Fixer Strip) to secure the l.c.d. behind the panel.

Drill switch and socket holes in the case to suit your preference.

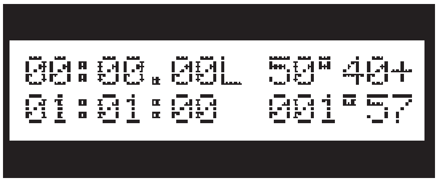
Details of obtaining the PIC and PC software, and pre-programmed PICs, are given later. The PIC program (ASM) was written using *Toolkit TK3* and a variant of the TASM dialect.

The hex code is MPASM-compatible and can be programmed into the PIC

using any standard PIC programmer. Configuration values are embedded in the hex code. You do not need to use the ASM code unless you wish to modify it.

Testing

Having proved the accuracy of the power lines, connect the l.c.d. and insert the d.i.l. i.c.s, including the pre-programmed PIC, correctly observing their orientation.



Typical LCD screen at very first switch on

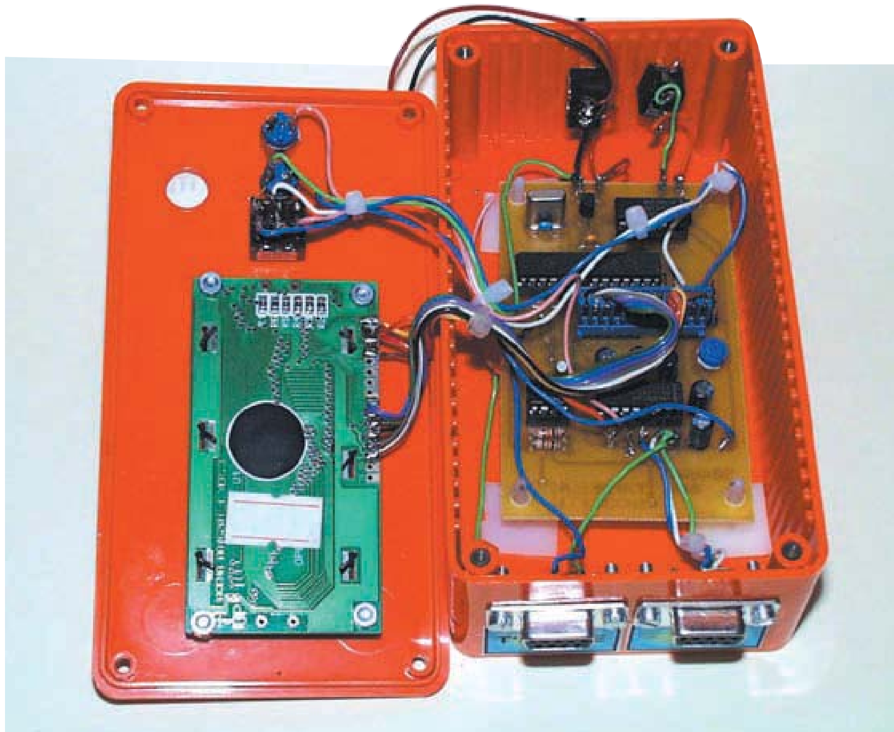
With switch S2 set to PC mode, check that when power is switched on the l.c.d. displays data similar to:

It will be necessary to adjust preset VR1 for a reasonable display contrast. At this time the latitude and longitude details will be those last used by the author. The clock and calendar data will be as above, with the RTC inactive until programmed for the first time by the PC.

The complete checking and use of the system follows in itemised sections. The earlier part assumes that the complete unit has been built.

PC Software

The PC software for the Telescope Interface should be copied onto the C:\ drive of your PC. Do not attempt to "install" it using Internet Explorer or similar – just copy it using Windows own Copy facility.



Within the folder are the PC software source code, written in Visual Basic 6 (VB6), and a standalone file Telescope Interface.EXE. Note that in order to examine the source code, you need not only VB6 installed, but also Joe Farr's excellent Serial OCX interface, discussed in *EPE* October '03. The source code will crash if Joe's software is not installed. It is available via the *EPE* Downloads site.

To run the standalone .EXE file, double-click on its icon, a moon symbol. The PC will show a screen similar to that in the screen dump, although the numerical values may be different.

When first run, this program's screen will show the settings last used by the author. After they have been changed as described below, the new settings will be loaded each time the program is then loaded and run.

Note that most options on the PC screen are only available when the PIC unit is connected to the PC.

Each screen button option will be discussed below, but first the Baud rate needs to be set identically for the PC, the PIC, the GPS and the telescope.

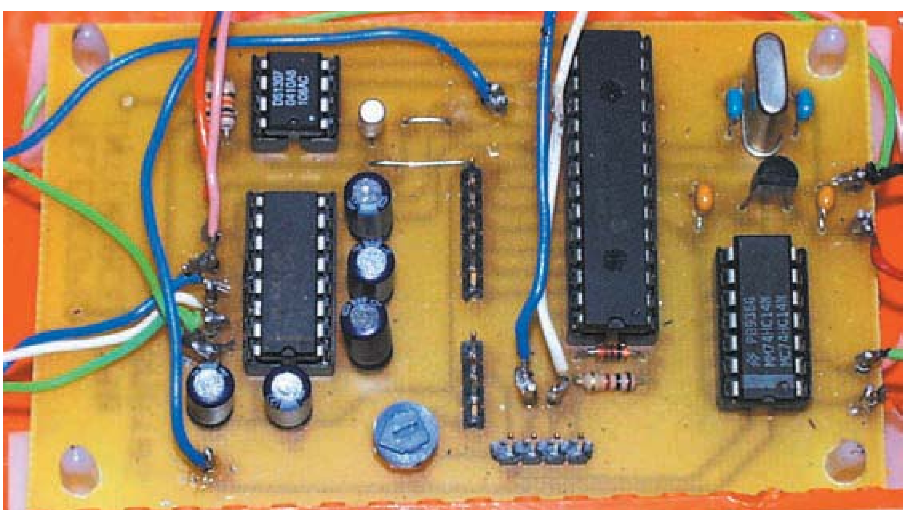
Set Baud Rate

Any one of four Baud rates may be used with this system (provided the GPS and telescope can also handle the selected rate):

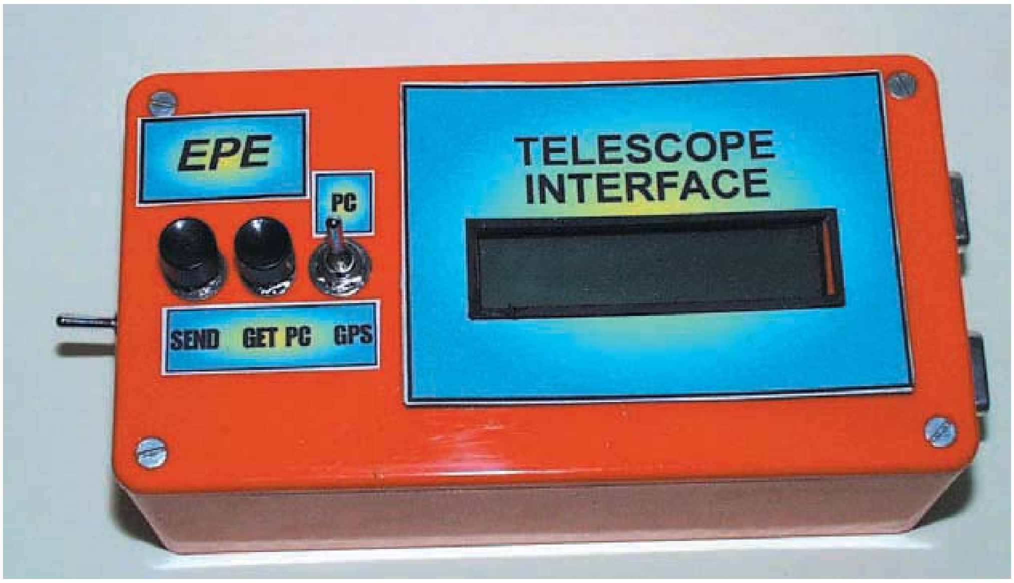
2400 Baud
4800 Baud
9600 Baud
19200 Baud

The default when the PC program is run for the first time is 9600, To select the PC's Baud rate desired, click on the Baud Rate combo box on the screen and click on the required rate. Then click the Save Settings button in order to store it to disk for future use.

To select the PIC's Baud rate, first switch off the PIC. Then press switch S4 and hold it pressed. Switch on the power to PIC. The screen will show the message Set Baud and the current Baud rate. The latter changes its value approximately once a second.



Prototype circuit board, before the l.c.d. backlight components were added. The lithium backup battery is also omitted



It continues to cycle through the four possible rates until S4 is released. When the Baud rate you want is seen, release S4. The Baud rate is then stored for future recall.

To select the Baud rate for the GPS and the telescope, consult their manuals.

The Baud rates may be changed by the same methods whenever desired.

Note that all four units must be set for the same Baud rate. A failure of communications will occur if they are not.

COM1 and COM2 Buttons

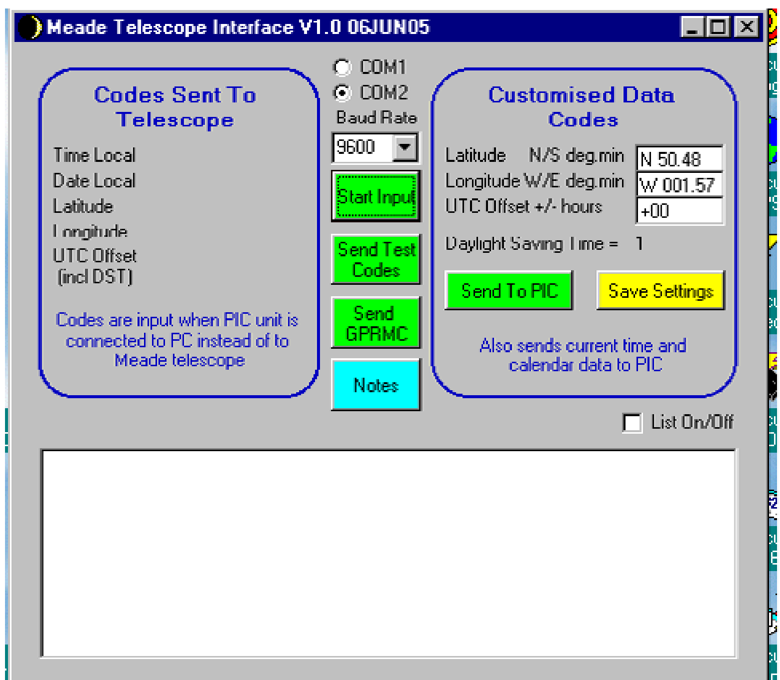
Next select the PC COM port you wish to use to communicate with the PIC, by clicking either the COM1 or COM2 button. The PIC unit cannot be used with a USB port. The selected setting is saved to PC disk when the Save Settings or Send To PIC buttons are pressed (see later).

Connect the PC to the PIC unit via a suitable standard "straight through" cable, such as is normally used with a typical modem.

Customised Codes Panel

It is into the Customised Codes panel that you enter the latitude, longitude and UTC offset values for your locality. They are used when the PIC unit is in RTC control mode (GPS not used). Latitude and longitude can be derived from a map of your area, or a GPS handset screen.

Latitude is prefixed by N or S, depending on whether you are in the northern or southern hemisphere. It is followed by a space, then the degrees as two digits (prefixed by 0 if less than ten), then a decimal point, followed by the minutes (segments of a degree), also as two digits.



PC screen shot showing the main setting-up buttons and the Code and Custom panels

Longitude is prefixed by W or E, depending on whether you are west or east of the Greenwich meridian). It is followed by a space, then the degrees as three digits (prefixed by 00 if less than ten, or 0 if otherwise less than 100), then a decimal point, followed by the minutes (segments of a degree), also as two digits.

The UTC Offset gives the basic number of hours difference between your time zone and the Greenwich meridian. It does not include any correction for Daylight Saving Time (DST). The value is preceded by plus or minus symbols depending whether you are west (-) or east (+) of Greenwich, thus the USA requires a minus (-) sign, and Australia needs a plus (+) sign.

Time zone differences are to be found via various sites on the web. Some geographical maps will give the information. A local bank should also be able to tell you.

Daylight Saving Time

Information for Daylight Saving Time is normally taken direct from the PC, which automatically updates its settings twice a year when DST is started or ended. When DST is on (1) one hour is added to the basic local time. When DST is off (0), standard time applies.

You do not need to take any action in respect of DST, the PC program itself obtains the information from the PC system. (Thanks to Joe Farr for providing the author with the VB6 code for doing this.)

Send to PIC Button

The data in the Custom panel is sent to the PIC by clicking the Send to PIC button. This action also sends the current time and date as known to the PC. It is important that the PC's clock is correct before the data

is sent. The basic data is stored to the PIC's non-volatile memory, with the time and date data being set into the unit's RTC chip. The PIC retains the data indefinitely until changed, even after main power switch-off. The RTC also retains its data after switch-off, providing the 3V Lithium battery (B2) has been installed.

The action also stores the Latitude, Longitude, Offset, Baud and COM port data to the PC's disk as file **Telescope-Settings.txt**, held within the same folder as the main code.

To send the data to the PIC, switch off its power, then switch S2 (GPS/PC) to PC, and switch on again. In this mode, the PIC's l.c.d. screen shows data held within the PIC's non-volatile memory, with the clock being updated from the RTC.

When this data is seen, press switch S3 (Get PC Data) to display the message Waiting PC Data, plus the currently selected Baud rate. Now click the Send to PIC button. The PIC handshakes with the PC in response to receiving this data, and the PC confirms it in its List panel.

The PIC confirms data receipt with the message Data Recd OK, plus the Baud rate. Release S3 when this message appears. The clock will then be seen to be updating with the current local time, and the date display will show the current calendar data. The latitude and longitude values will be those you have selected via the PC screen.

It should be noted that the first time the PIC unit is ever switched on, or if the 3V backup battery (B2) is not installed, or is flat, the RTC will at first be inactive, and the time will appear unchanging as 00:00.00L (L stands for Local), with the date as 01:01:00. The Send To PIC option must be used to start the RTC running.

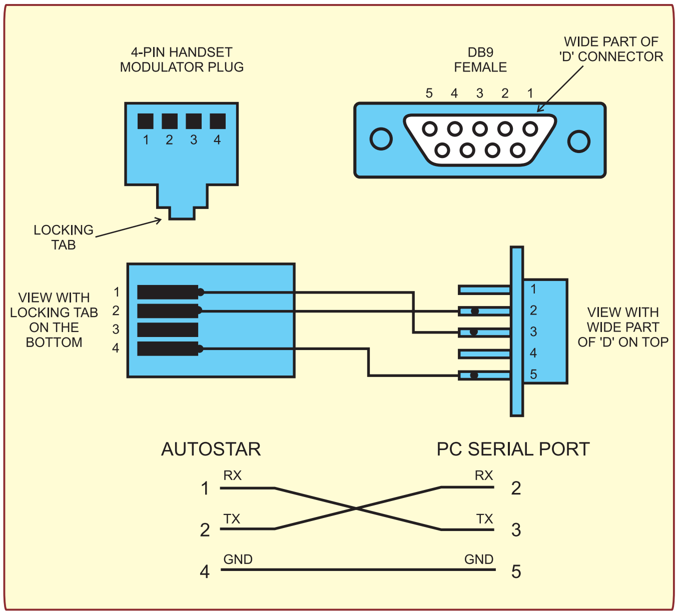


Fig.3: Meade's own cable wiring details

Save Settings Button

Clicking the Save Settings button stores the latitude, longitude, UTC offset, Baud rate and COM port data to the PC's disk as file **TelescopeSettings.txt**, as with the Send To PIC button, but without sending it to the PIC. It is recalled next time the program is run.

Start Input Button

The Start Input button allows data processed by the PIC, for normally sending to the telescope, to be input to the PC for display in the left-hand panel.

To set the PIC unit for outputting data to its RS232 connector (SK1), first switch off the unit, switch S2 (GPS/PC) to the PC setting and then switch on the unit again. Plug the selected PC COM port (see above) into socket SK1. Now click the Start Input button. The button then disappears and is replaced by a Stop button.

When switch S4 (Data Output) is pressed, data is now sent from the PIC to the PC in the code format required by the telescope. It is received by the PC as a non-synchronous stream of data. After each block of 64 bytes is received, the sentence is split into its various sub-sections. Using the prefix codes of these sections, they are allocated to the respective display lines in the left-hand panel.

The two ends of the case showing the GPS input socket and the Telescope and PC serial connectors

You may also examine each data block and its sub-sections by clicking the List On/Off box so that a tick appears. Data is then also output to the List area as text. Clicking the List On/Off box again turns the listing facility off. It is an alternating cycle.

To stop data input, click the Stop button.

When the PIC is in this mode, the data may also be input by the PC through its Hyperterminal function (Baud rate as selected, 8 data bits, 1 stop bit, no parity).

Telescope Codes Panel

The Time, Date and UTC Offset data output from the PIC to the Telescope Codes panel (as well as to the telescope) is corrected to Local Time, as discussed earlier.

Time is shown in order of hours (24-hour clock), minutes, seconds. Date is shown in order of month, day of month, year.

Latitude is shown prefixed by plus or minus symbols. A plus symbol indicates that the latitude is in the northern hemisphere, with minus for the southern. Longitude is expressed relative to 360 degrees.

The UTC Offset received from the PIC includes the DST value. If DST is active (1), the offset value will be one greater than the offset value set into the Custom Codes panel.

Mode Summary

SET PIC BAUD RATE
Switch off PIC
Press S4 and hold it pressed
Switch on power to PIC
Release S4 when required Baud shown

SET RTC DATA
Switch off PIC
Switch S2 (GPS/PC) to PC
Switch on power to PIC
Press S3 (Get PC Data) and release
Click PC's Send to PIC button

SET DST MANUALLY
Switch off PIC
Press S3 and hold it pressed
Switch on power to PIC
Release S3 when required DST shown

SET UTC OFFSET MANUALLY
Switch off PIC
Press S3 and S4 together and hold them pressed
Switch on power to PIC
Release S4 when required Offset shown
Release S3

SEND TEST DATA TO PIC
Switch off PIC
Switch S2 (GPS/PC) to GPS
Switch on power to PIC
Switch S2 (GPS/PC) to PC
Click PC's Send Test button

SEND GPRMC DATA TO PIC
Switch off PIC
Switch S2 (GPS/PC) to GPS
Switch on power to PIC
Switch S2 (GPS/PC) to PC
Click PC's Send GPRMC button

OUTPUT TO TELESCOPE OR PC (GPS use)

Switch off PIC
Switch S2 (GPS/PC) to GPS
Switch on power to PIC
Press S4 (Data output) to output data
Release S4 to stop output

OUTPUT TO TELESCOPE OR PC (no GPS)
(RTC must be installed for this mode)
Switch off PIC
Switch S2 (GPS/PC) to PC
Switch on power to PIC
Press S4 (Data output) to output data
Release S4 to stop output

Send Test Button

Clicking the Send Test button loads a pre-recorded data file to the program, which then outputs various GPS sentence codes to the PIC for processing as though they were real GPS data coming in from a handset. This allows the unit to be tested without a GPS handset connected.

The file was recorded in June 2003 and shows data applying at that time. It includes all the possible GPS code sentences which are likely to be received by GPS receivers. It was recorded via a Garmin GPS12 handset. The $GPRMC sentence is the one which includes the data used by this Telescope Interface.

To use this option, first switch off the PIC unit, then switch S2 (GPS/PC) to the GPS setting, after which switch on the unit. When the l.c.d. screen shows the Waiting For Signal message, switch S2 back to the PC setting. Now click the Send Test button. The unit will receive the data from the PC, but process it as if it were from a GPS unit, displaying the information on the l.c.d.

Having output the data block to the PIC, it starts from the beginning again, so only two different times are ever shown. Click the Stop button to end the output.

The purpose of this option is to test the PIC, not for sending code to the telescope.

Send GPRMC Button

The function of the Send GPRMC Button is similar to the Send Test Button, but the GPS sentence sent is just $GPRMC data with your current local time converted to UTC. Because the data sending is not fully synchronised, a Checksum error may occasionally be reported by the l.c.d. Correct receipt should resume automatically.

During this mode, the list box is hidden and instead the GPS sentence details plus UTC and PC time are displayed.

The purpose of this option is to test the PIC, not for sending code to the telescope.

Be aware that as data transfer is asynchronous, the clock's seconds value may sometimes miss a second, jumping, say, from 1 to 3.

Just for interest and not for use by the telescope, in this mode the Sidereal Time is also displayed. On one line is shown the current time in relation to the Greenwich meridian (GMST), the other line is the sidereal time in relation to the user's location (LMST).

GPS Interfacing

Before connecting the GPS handset to the PIC unit, check its manual for the output connections. Only those for the output signal and 0V are required. Connect the GPS unit via a suitable socket (SK2), plug and cable.

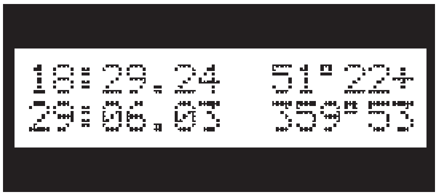
Set the GPS handset to output GPS data according to NMEA 0183 protocol at the same Baud rate selected for the PC, PIC and telescope.

With the PIC unit switched off, set switch S2 to the GPS position, then switch on the power.

Once the GPS has acquired signals from the "local" satellites, data is output from it and assuming connections between the PIC and GPS are correct, the PIC will select the $GPRMC data sentences, extracting the codes discussed earlier.

Display

Data will be displayed on the l.c.d. screen similar to the following, with local time showing (subject to DST and UTC Offset having been set).



L.C.D. screen receiving test codes from PC

Following the conversion, data is ready to be output to the telescope. This can be sent when required by pressing switch S3 on the unit. It is output at the selected Baud Rate, formatted for the Meade as discussed earlier.

Manually Set DST

For those who wish to set DST manually, i.e. those who have not installed the RTC and do not wish to interface to a PC, the procedure is similar to setting the Baud rate.

To select the PIC's DST value, first switch off the PIC. Then press switch S3 and hold it pressed. Switch on the power to the PIC. The screen will show the message Set DST and the current DST value. The latter changes its value approximately every one second. It continues to cycle through the values 0 and 1 until S3 is released. When the DST value you want is seen, release S3. The DST value is then stored for future recall.

Manually Set UTC Offset

To set the UTC Offset manually, switch off the PIC. Press switches S3 and S4 together and hold them pressed, then switch on the power. Do not release the switches.

The screen will show the message OFFSET and the offset value, initially as +00. The latter increments its value approximately once a second. It continues to cycle through the values +00 to +12, and then -00 to -12 and then to +00 etc again until S4 is released. When the Offset value you want is seen, release S4. Then release S3. The Offset value is then stored for future recall.

Self Contained Unit

This Telescope Interface may be used to send data to the telescope without a GPS unit connected, provided the required settings and time/date data have been sent to the PIC.

To set the PIC unit for outputting to the telescope, first switch off the unit, switch S2 (GPS/PC) to the PC setting and then switch on the unit again. Plug the telescope into the PIC unit. The PC does not need to be connected for outputting to the telescope in this mode.

When switch S4 (Data output) is pressed, data is now sent from the PIC to the telescope in the code format required. Check that the telescope confirms that it has received the data.

GPS Only Unit

The unit may be used without the RTC and PC interfacing, relying on GPS handset data input only. All data then comes from the GPS handset, except for DST and UTC Offset, which must be set manually, as described earlier.

Resources

Software, including source code files, for the Telescope Interface is available for free download from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under Telescope Interface. Download all the files within that folder.

Ready-to-go programmed PIC16F876 microcontrollers for the Interface project are available from Magenta Electronics

The PIC program source code (ASM) was written using *TK3* software (also available via the Downloads page) and a variant of the TASM dialect. It may be translated to MPASM via *TK3* if preferred.

The Meade website is at **www.meade.com**. Information on GPS handset manufacturers can be found by searching on their name via **www.google.com**. Finally, if you are looking for sources of live sidereal time, try: **http://tycho.usno.navy.mil/sidereal.html**

www.jgiesen.de/astro/astroJS/siderealClock

The sidereal code used in the PC software was adapted from Keith Burnett's web information accessible via: **http://bodmas.org/kepler/sidinfo.htm.**

It is worth a browse as it explains clearly what sidereal time is, and provides a worked example in Basic of it in use.

Another site you may find useful is at **www.qsl.net/SARA/educ/tutor1.htm**.

For ex demo and refurbished Meade telescopes browse **www.telescopehouse.co.uk**.

Acknowledgements

The author gratefully thanks Jason Kotecki for inspiring this idea and field testing the design with his Meade LX200 telescope. Jarr Farr is also warmly thanked for his DST VB6 code.

EPE

PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Using the RS485 Protocol for Serial Comms

Although many advances have been made in wireless communications, long distance wired links still have their place. There are many reasons to avoid an RF solution: cost, complexity and interference being some of the more obvious ones.

The RS232 protocol is probably the most ubiquitous wired communication solution and is certainly not difficult to implement on a PIC using a device such as the MAX232 chip. RS232, however, does have some significant limitations. The standard defines the maximum cable length to be only 15 metres, and while you will probably achieve greater distances with good wiring, you will need to use low data rates and be in a noise free environment.

The main problem is that the data signals are defined relative to a common ground; as the distance increases, noise induced on the ground signal will cause data corruption. When the communicating devices are close together, such as a PC and a modem, this is unlikely to be a problem. But imagine if the devices are a mile apart – a lighting strike or mains surge close to one unit will cause a significant imbalance in the ground potential, easily perturbing communications reliability.

Another limitation of RS232 is that it is a point-to-point standard. Only two devices may be connected together. So if you want to talk to a device a mile away, or talk to a network of devices in an electrically noisy environment such as a factory, you need another solution.

RS485 Protocol

RS485 protocol is one of the standards introduced to solve that problem. It's not the only standard, but has been one of the most popular in recent years, and is very easy and cheap to implement – hence its popularity.

RS485 was introduced in 1983 as an improvement to the similar standard RS422. The main difference between RS485 and RS232 is that RS485 uses a two wire differential voltage method to transmit data. The polarity of the signal between the two wires determines the logic level; the ground signal is only used as a return path for the current. If the differential signals were exactly complimentary then they would cancel out and there would be no return current, but the real world dictates that there are some small imbalances, hence a common ground signal is required – more on this requirement later.

RS485 is specified to work at up to 10Mbs and a distance of up to 4000 feet – but not both at the same time! With 24awg twisted-pair wire and just two devices you can expect under ideal conditions to get up to 1Mbs at 200 feet falling to 100Kbs at 4000 feet.

As a differential voltage based system, two wires are required for each signal. There are no control signals such as RTS or DTR specified, so all flow control and handshaking must be done within the application. To help reduce the effect of noise the pair of wires should be twisted, although it is not essential over shorter distances.

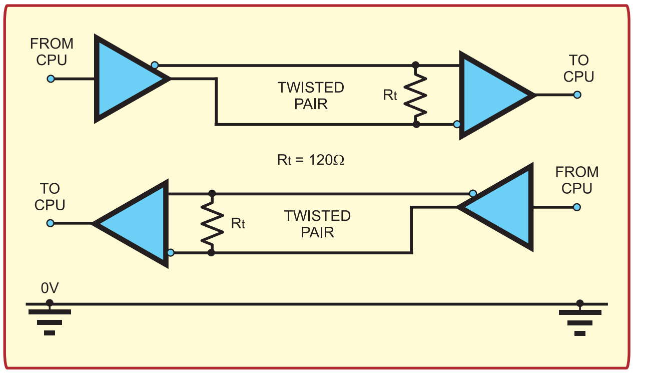


Fig.1. Simplest RS485 setup

Topologies

There are several topologies (layouts) for how devices can be connected together. Fig.1 shows the simplest setup using five wires. One pair for transmitted data in each direction, plus ground. The resistors Rt in Fig.1 are termination resistors.

Why are they required? The cabling (bus) connecting the devices is a transmission line, and will typically have an impedance of between 100Ω to 120Ω, assuming you are using twisted pairs. The RS485 receiver's input impedance will be very high, typically about 12kΩ, and if the transmission line is not terminated with a similar impedance then the signals will be reflected back towards the transmitter, corrupting the data in subsequent signals.

This setup will generally provide the greatest range/speed combination but does require five wires which can be costly over long distances. This problem is eased by using a single twisted-pair for both transmit and receive data with the use of driver ICs that can place the transmitter into a high impedance state. Fig.2 shows a typical multi-device setup.

Note now that there is a termination resistor Rt at both ends of the transmission line, since data is travelling in both directions. Two further resistors (Rb) provide bias to the differential signals for when there is no transmitter driving the bus line. Without these the receivers will effectively "float" and produce random data.

This combination of biasing, additional termination and the presence of multiple receivers on the bus will naturally reduce the maximum distance/bit rates achievable compared to Fig.1, so don't expect 100Kbits at 4000 feet if you have multiple devices on a single twisted-pair!

Multiple Device Care

If you build a multiple device network you need to be careful how you connect devices to the bus. The distance between "midway" devices and the main transmission line (such as B and C in Fig.2) must be kept short, otherwise your setup will look more like a star connected network than a chain. Midway devices will appear to be at the end of un-terminated transmission lines, and reflections will occur.

Although unlikely to be a problem on short networks, as the distance increases so more attention should be paid to transmission line termination. The simple rule: keep your midway connection "stub" wiring as short as you can, daisy chaining if possible.

The RS485 standard states that "up to 32 devices may be connected on a bus". Driver IC manufacturers, however, have produced devices with 1/4 and 1/8 the load of a standard device, so actually up to 256 devices may be connected. You will often see manufacturers' datasheets quoting parts as being "1/4th Load Unit" (MAX1487 for example) and these devices should be used if you expect to have many devices on the bus.

Tx/Rx Handshaking

The lack of control signals means that handshaking and determining which transmitter should be active on the bus must be handled in the application software. Typically one device will be the master; it will talk to the other devices (slaves) and will place its transmitter into a high impedance state if the addressed slave is expected to reply. The slaves will monitor the data on the bus and only enable their transmitter driver when requested to by the master.

A PIC microcontroller's serial port module provides a very useful feature for handling multiple device addressing: a 9th bit option. This bit, used in conjunction with the PIC's receive interrupt, enables a PIC

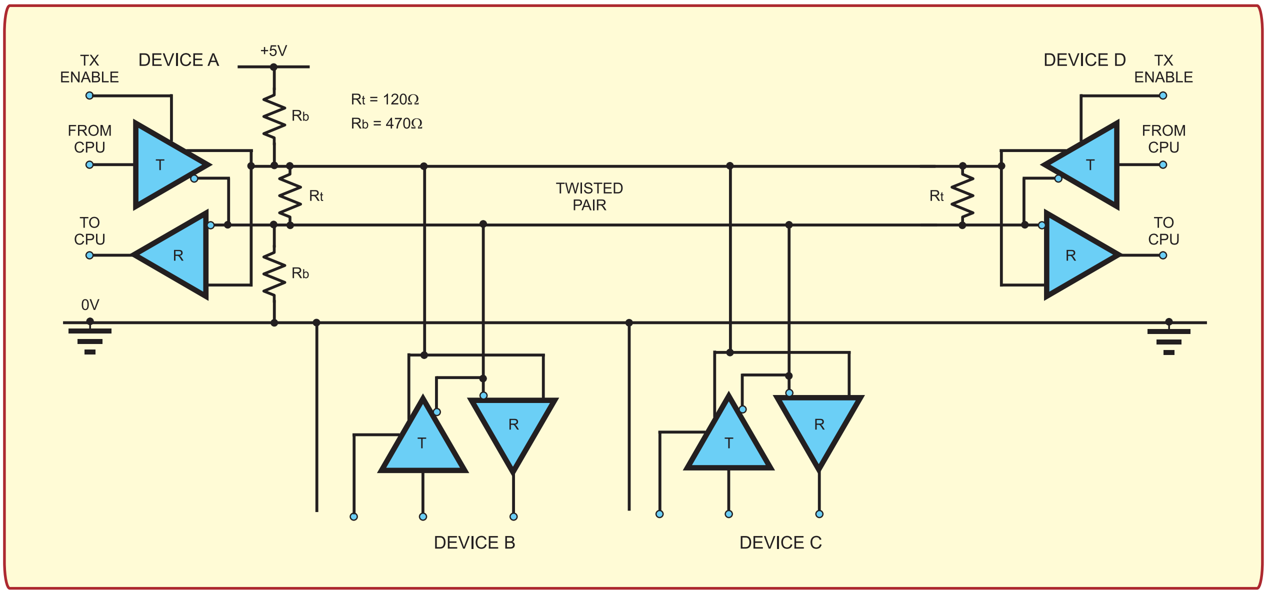


Fig.2. A typical RS485 multi-device setup

to ignore all serial data except address bytes. The PIC can remain in a low power state and only wake up fully when it is individually addressed. It's not essential, so you can use ordinary 8-bit serial communication if you wish, but it is certainly worth experimenting with if you want to reduce the amount of processor time spent monitoring bus communications.

RS485 Devices

There are plenty of RS485 transceiver ICs available, and many of them are pin compatible with each other. National Semiconductor's DS1487, DS75176, Texas Instruments' SN75LBC184, and Maxim's MAX483E and MAX1487, will all work in the same design. There are, however, some key differences between the parts. The important ones are to do with slew rate limiting and ESD protection.

Slew rate limiting is the shaping of the signal edges to reduce high frequency signals and consequently the amount of noise generated by the bus. It does, however, reduce the maximum data rate. The slew rate controlled MAX483E, for example, operates up to 250Kbs, while the MAX1487 can operate up to 2·5Mbps.

The ESD protection offered by these devices also varies enormously. While the DS75176 device is very cheap, it only offers up to 500V ESD protection compared to the (more expensive) MAX483E which offers 15kV! We have chosen the DS75176 as an example simply because it is cheap, easy to obtain and works fine in a domestic environment.

In Fig.3 are shown the microprocessor connections to the DS75176 when used in a multi-drop configuration such as that in Fig.2. It is very straightforward as (unlike RS232) the bus does not require higher voltages to be generated. Only the bus resistors and a couple of supply decoupling capacitors are required to complete the electronics.

The IC has independent enable signals for the transmitter and receiver but in most cases you can wire the receiver enable signal to ground as shown to permanently enable it. A consequence of this is that all transmitted data is echoed back to the receiver, a kind of "local echo". Alternatively, the enable signals can be wired together so that when the transmitter is enabled, the receiver is automatically disabled.

Software

The microcontroller must only enable the transmitter while it is actually sending data, and it must be careful not to send data when another device on the bus might send data – the driver contention could destroy one or both ICs. Obviously you need to take care with the software at both ends of the wire!

A typical way to do this is to decide on a message transmission protocol to be implemented by the master and all slave devices. For example, precede any data to be sent with an address byte and data length byte. The master device will specify the device it wants to talk to in the first byte, and indicate how many bytes will follow in the second. This technique will work with ordinary 1-start bit, 8-data bits, 1-stop bit serial port setups. You can improve the reliability of the system by adding a check byte to the end of the message.

An example of a master/slave application is provided in this month's *PIC N' Mix* zip file on the Downloads section of the *EPE* website (access via **www.epemag.co.uk**). In this design the master polls a number of slave devices on the bus, and each slave returns the values on an input port. Although the software does nothing useful it can be used to test an RS485 setup, and provide a framework for further experimentation.

Construction Consideration

When building the interface electronics, it is important to consider the vulnerability of the driver IC. Being on the end of a potentially long wire it may pick up excessive noise that may destroy it. Unless your bus is very short, you should always use an IC socket for the bus transceiver IC. Although the ICs are inexpensive, they will be a lot easier to replace if socketed!

You should also place 100nF and 10μF capacitors across the supply to the IC, and keep the leads of these as short as possible. More advanced techniques for use in very noisy areas are possible, including adding transorbs (voltage suppression diodes) across the bus wires to protect against very high voltage spikes.

Conclusion

So there you have it. Using RS485 to communicate with other microcontroller circuits can be quite simple and in some cases easier than RS232. Although we have only discussed 5V interface ICs here, 3V parts are also available for low power design. RS485 networking can appear complex and confusing, but hopefully this article will ease your entry into the application of this useful and versatile tool.

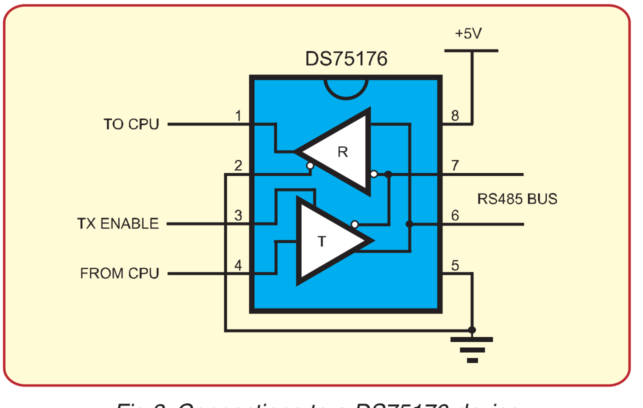


Fig.3. Connections to a DS75176 device

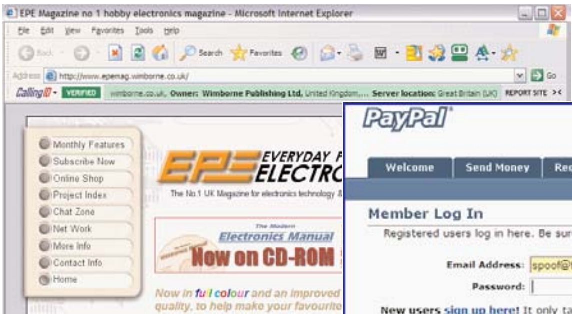
Net Work

Alan Winstanley

AT the time of writing, High Street retailers are licking their post-Christmas wounds. There is no doubt about it – the Internet's time has come, helped by the increasing availability of broadband and dirt-cheap computer equipment. Taking the car, beating the traffic, scouring the High Street and fighting through thronging crowds is so yesterday!

One third of all UK seasonal shopping was done online last year with a vast increase of Internet trade compared with 2004. Amazon UK peaked at up to 3·6 million items per day in the run-up to Christmas. In comparison, it was reported by YouGov that users' perception of quality and value provided by eBay sellers actually fell during the Christmas 2005 period.

Mind you, all is not quite perfect at **Amazon.co.uk**: the writer still finds it impossible to pay by Maestro because the checkout form contains fields that ask for non-existent card data. And when trying to increase an order value to achieve free P&P, it can take ages scouring for other appealing products that may turn out to be out of stock anyway. Sometimes, nothing beats the tactile experience of real shopping.



The Calling ID toolbar can help identify web site owners

Gone Phishing

Much has been written to alert Internet users about "phishing" attacks – unsolicited emails that entice recipients into logging into deceptive versions of their online accounts, thereby enabling fraudsters to capture password details. Phishing attempts are still widespread and whilst some efforts are truly risible, some are deceptively authentic-looking. Even battle-hardened users occasionally have to stop and slap their foreheads, just before they type their passwords into the login page of an enterprising Romanian's interpretation of HSBC Bank's global website.

One clue that a phishing web site cannot be authentic may be contained in the address (URL) of the phisher's target site. It is intended to fool inexperienced users sufficiently into thinking they are accessing the real thing. Also, such sites are usually insecure and therefore have no golden padlock icon. A phisher may try, for example, **http://https-paypal-secure//access.loginwibble.com** or similar device. The author's preferred Eudora Email software (free download from **www.eudora.com**) warns when hopping to these deceptive URLs.

It is worth re-emphasising that no online institution will ever email you asking you to log in to a web site to re-confirm your details. Also, if you were a genuine customer anyway, then they would always address you by name, and not by "Dear PayPal Customer". If eBay wishes to communicate with you, messages are copied to your eBay account that you can view when you log in the usual way.

CallingID Toolbar

A new toolbar that runs in Internet Explorer has been produced by CallingID which displays web site ownership details where available (see screenshots). If the address has previously been assessed as high risk (e.g. a phishing site) then a popup warns you before you enter a login. The results aren't always entirely useful, because they depend on the accuracy of domain name databases, but the CallerID offers the tool for free and it has produced some interesting results during tests. Check **www.callerid.com** for details of the free download. Another anti-phishing toolbar that has also been tested is available free from **http://toolbar.netcraft.com**.

Perhaps the tide is starting to turn against the phishers. In the UK a phishing scammer named as David Levi was convicted late last year of defrauding eBay customers out of some £200,000, and he received a four year jail sentence for his trouble. His brother was jailed for 21 months for conspiring to defraud.

Calling ID tries to warn when logging into suspicios sites

Another form of fraud that has hopefully been all but eliminated is "second chance" fraud, in which eBay bidders who narrowly missed out on an item are contacted by fraudsters posing as the original seller, to offer the losing bidder a second chance. A funds transfer by Western Union would be requested. Needless to say, the thieves would then disappear with the money into the night. It was reported that a couple from Romania made nearly £1/3rd million this way before they were caught in London and jailed for six years. eBay no longer permits Western Union payments for items.

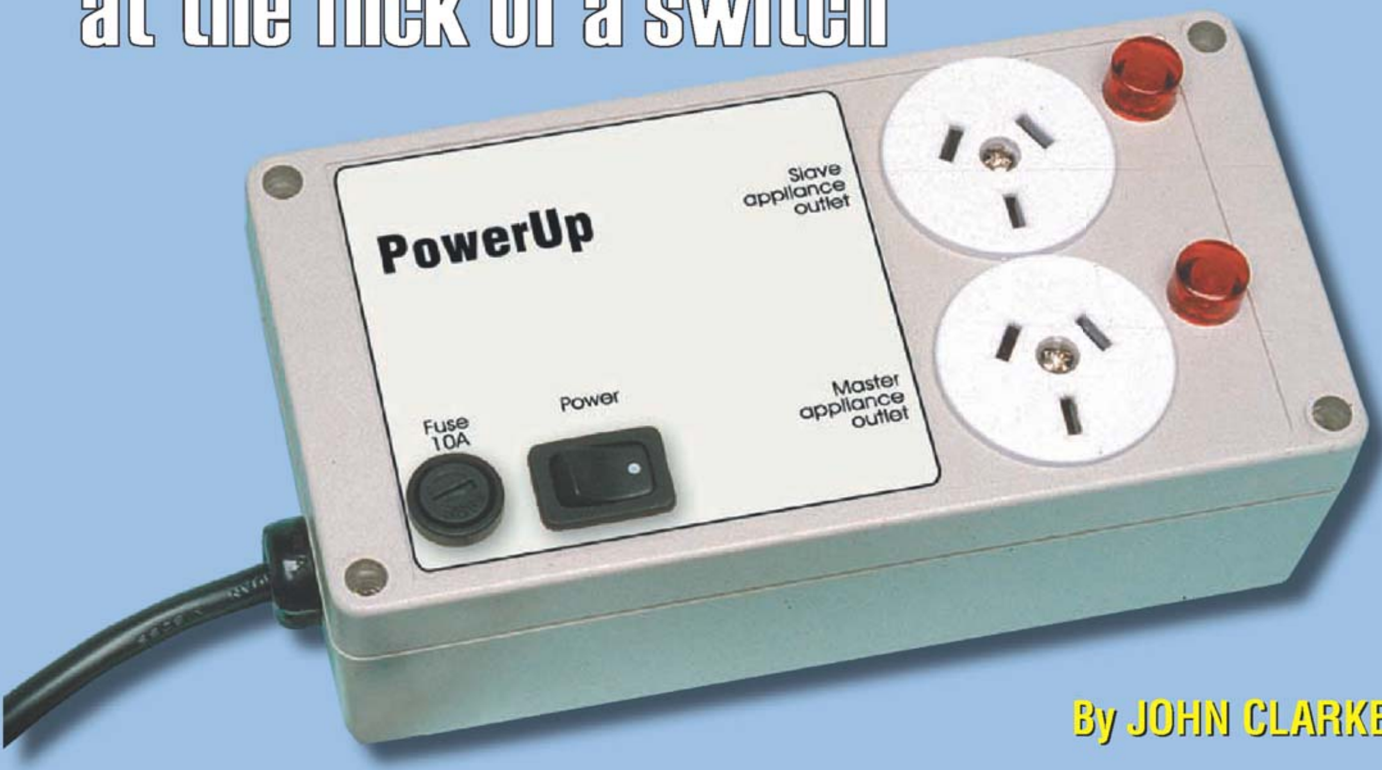
An eBay item can be linked as a shortcut so that it is a double click away

I round off this month with a handy tip for eBay users: if you wish to track a particular item, then apart from storing it in "My eBay" you can drag and drop the weblink from your web browser, directly to the desktop underneath. The shortcut on your desktop (see graphic) shows the item number, description and expiry time, and it is just a double click away. The same trick applies to any other web site.

You can email the writer at **alan@epemag.demon.co.uk**

PowerUp

Turns on all your equipment at the flick of a switch



By JOHN CLARKE

Switch on your PC and your peripherals will come on as well. Switch on your amplifier and all your hifi gear will come on too. Switch on your TV and the rest of your home theatre system will power up as well. That's the beauty of this "PowerUp" unit.

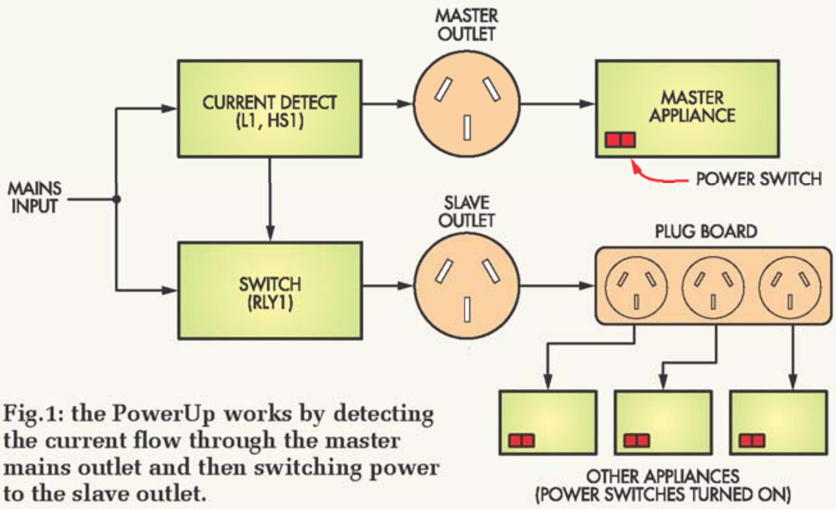


Fig.1: the PowerUp works by detecting the current flow through the master mains outlet and then switching power to the slave outlet.

YOU CAN ALSO USE PowerUp in your workshop. Switch on your router or bench saw and the vacuum cleaner will suck away the sawdust straightaway. Doubtless there are other applications to save you switching on numerous other items of equipment when you want to get straight into work or play.

The PowerUp connects to the main unit such as an amplifier and switches on power to the remaining units whenever the main unit is switched on. This saves having to power up the other units separately.

PowerUp is a small box with two mains outlets, one for the master appliance and the other to run the slave appliances. This second outlet would provide power to a multi-way powerboard for the remaining appliances. (The sockets shown in the photographs are Australian mains sockets but these can be replaced by whatever sockets are used in your country i.e. 13A mains sockets or IEC sockets in the UK.) When the master appliance is switched on, the other appliances will be powered up also.

PowerUp works by detecting the current flow through the master mains outlet and then switching power to the slave outlet. The general scheme is shown in the block diagram of Fig.1. The current detector is a toroidal coil combined with a Hall effect device.

Circuit description

The full circuit is shown in Fig.2. Besides the Hall effect device, it uses just two ICs and a relay. The Hall sensor is placed in a slot (air gap) in a toroidal core. The master outlet current flows through the toroidal coil and generates a corresponding AC signal from the Hall sensor (HS1).

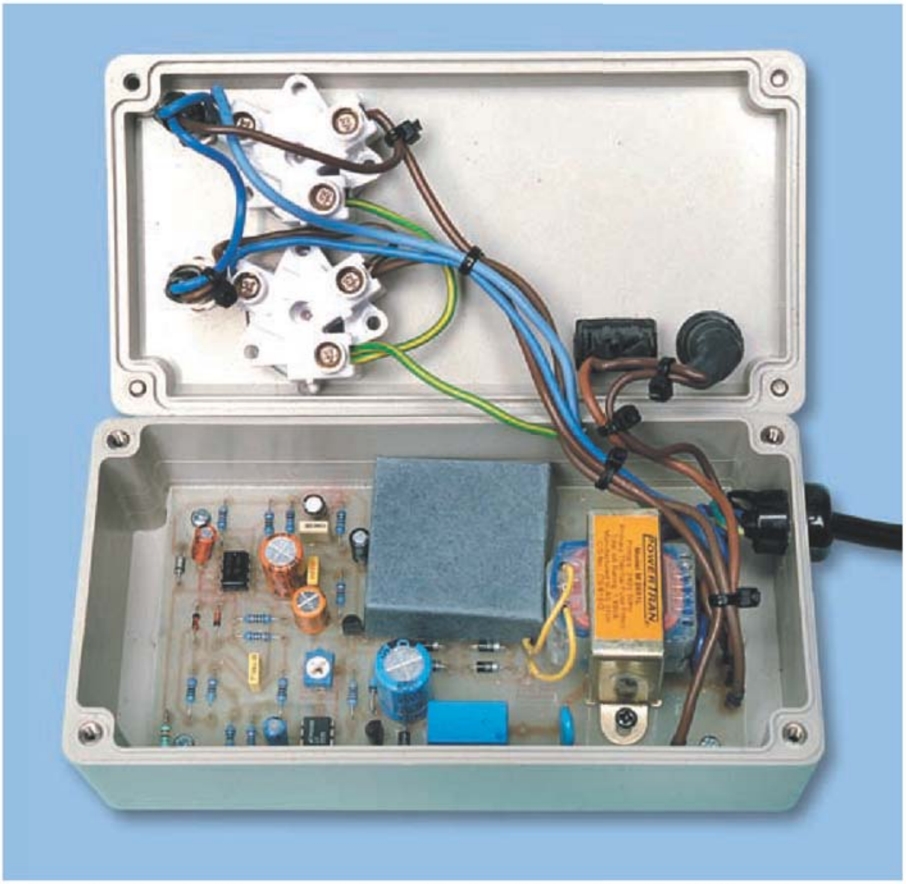
Its output is filtered with a 1kΩ resistor and 1µF capacitor which rolls off frequencies above 159Hz. The filtered output is then AC-coupled to pin 3 of op amp IC1a. Pin 3 is biased at +5V via the 100kΩ resistor from the +5V rail.

Op amp IC1a is set for a gain of 471 using the 470kΩ feedback resistor from pin 1 to pin 2 and the series 1kΩ and 10µF capacitor to the +5V rail. The 10µF capacitor rolls off frequencies below 16Hz. Frequencies above 154Hz are rolled off by the 2·2nF capacitor across the 470kΩ feedback resistor between pins 1 & 2.

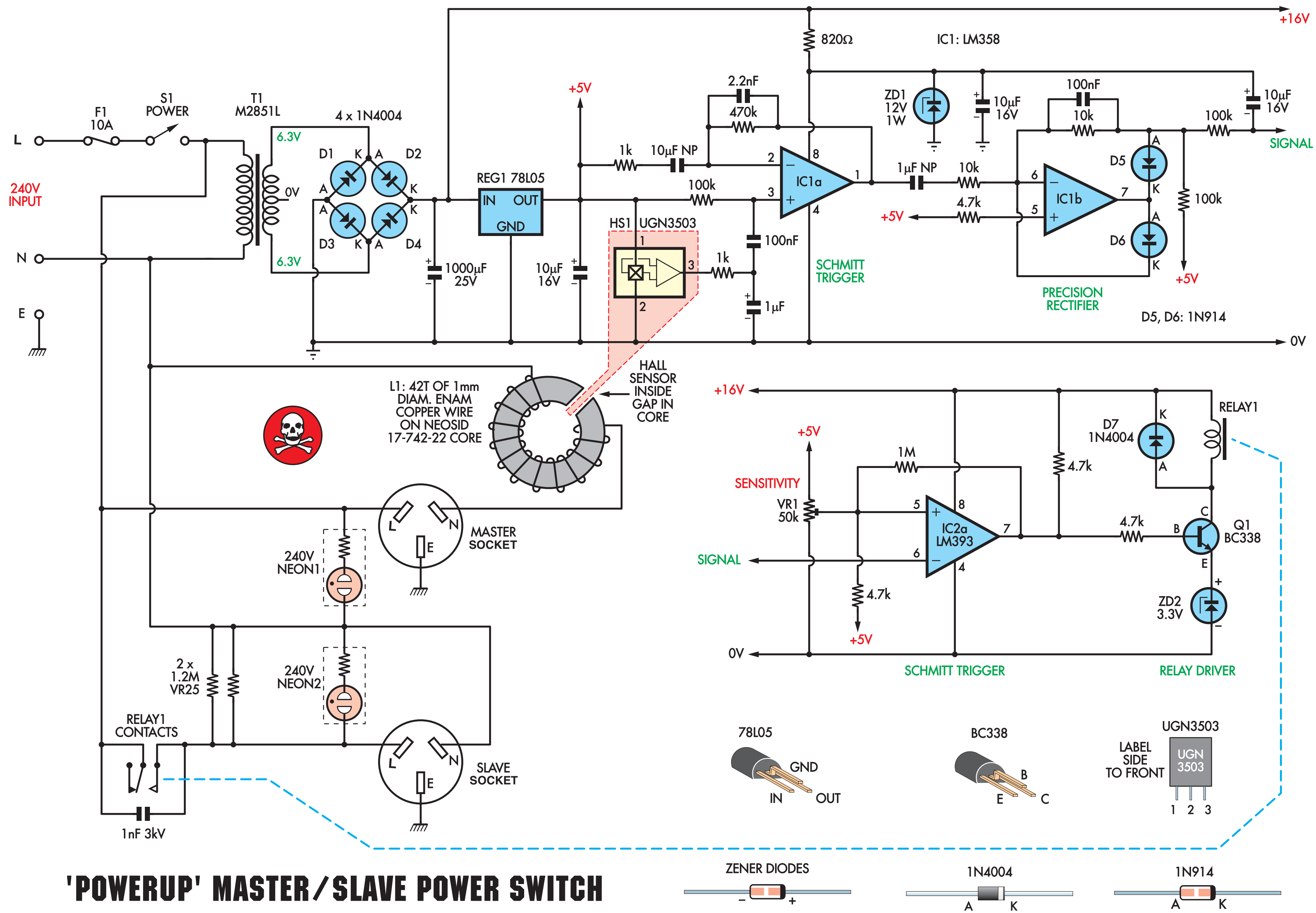
Op amp IC1b is wired as a precision half-wave rectifier by virtue of diodes D5 and D6 which are connected within the feedback loop. The rectified signal at D5's anode is filtered with a 100kΩ resistor and 10µF capacitor so that the result is a DC voltage proportional to the signal from the Hall sensor.

IC2a is half an LM393 dual comparator wired as a Schmitt trigger. It monitors the filtered DC signal at pin 6 and compares it to the threshold voltage at pin 5. Pin 5 is connected to the 5V rail via a 4·7kΩ resistor and also to trimpot VR1 across the 5V rail. A 1MΩ positive feedback resistor to pin 7 applies hysteresis.

Hysteresis means that the pin 5 voltage is at a different level, depending on whether the output at pin 7 is high

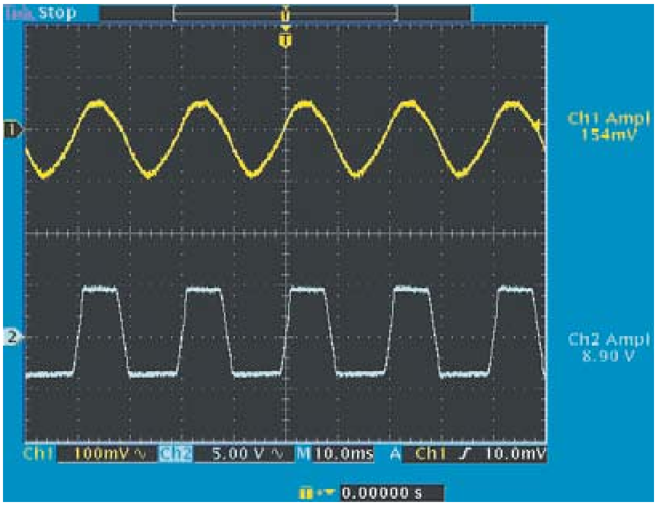


This is the view inside the prototype. The toroidal coil on the PC board operates at mains potential and is protected by a plastic insulation cover (see text).

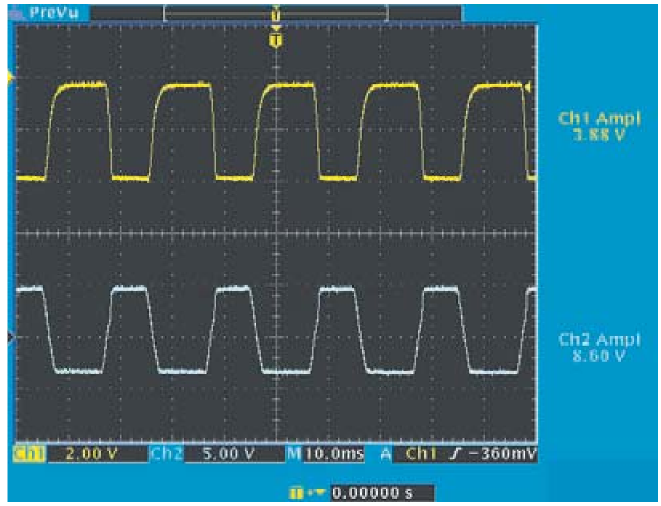


'POWERUP' MASTER/SLAVE POWER SWITCH

Fig.2: the complete circuit diagram. IC1a amplifies the signal from the Hall sensor and feeds it to precision rectifier stage IC1b. IC1b's output is then fed to Schmitt trigger stage IC2a which drives Q1 and the relay to switch in the slave socket.



In this oscillogram, the top trace shows the Hall effect signal when connected to a 60W mains load. This is amplified to 8·9V peak-to-peak by IC1a (lower trace).



IC1a's output (lower trace) is rectified by IC1b (top trace). This rectified signal is filtered and fed to the Schmitt trigger to control the relay.

or low. When pin 7 is low, pin 5 is pulled a few millivolts lower via the 1MΩ resistor and if pin 7 is high, pin 5 is pulled a few millivolts higher. This ensures that small variations in DC input voltage to pin 6 do not cause the output to oscillate high and low.

Trimpot VR1 sets the trigger threshold for IC2a. This is normally set at around mid-position. Setting it slightly towards the 5V supply will trigger the Schmitt at small signal levels from IC1b, while setting it towards the 0V rail will mean that the signal needs to be greater before IC2a's output will go high.

When pin 7 of IC2a does go high, it drives transistor Q1 to turn on relay RLY1 which then applies 240V AC to the slave socket.

The 3·3V Zener diode in Q1's emitter to ground connection reduces the voltage applied to the relay to around 12V rather than above 15V.

Power for the circuit comes from a 12·6V transformer. It drives a bridge rectifier (D1-D4) and a 1000µF capacitor to provide about 16V DC. This supplies IC2 and the relay. IC1 is powered from +12V, derived using a series 820Ω resistor and 12V Zener diode (ZD1). The Hall effect sensor is fed with 5V from a 78L05 regulator (REG1) and this also provides the input reference for IC1a, IC1b and IC2a. IC2b is not used.

Mains power indication

Both mains sockets have a neon indicator wired across them to indicate when power is present. Neon 2, across Live and Neutral for the slave outlet, lights when the relay contacts are closed. The relay contacts are shunted with a 1nF 3kV capacitor which prevents contact arcing when power is removed. The capacitor also allows a small amount of current to flow when the relay is open and this is sufficient to dimly light Neon 2 even though it has two 1·2MΩ resistors connected across it.

In practice though, this is not a problem because Neon 2 lights quite brightly when it should; ie, when power is available at the salve socket.

Construction

The PowerUP circuit is built on a PC board measuring 79 x 140mm (available from the *EPE PCB Service*, code 557). It is housed in a plastic case measuring 165 x 85 x 55mm, with two chassis-mount mains sockets on the lid.

Note that you must use a plastic case for this project and there must be no exposed metal parts that pass through to the live wiring area inside. DO NOT use a metal case for this project – that would be too dangerous.

You can begin assembly by checking the PC board against the published pattern of Fig.6. There should not be any shorts or breaks between tracks. If there are, repair these as necessary.

Next, insert and solder the PC pins and the resistors. Use Table 2 as a guide to the colour codes for the resistors. **Note that the two 1·2MΩ resistors must be high-voltage Philips VR25 types or equivalents. Do not substitute for these.**

Next, insert and solder in the Zener diodes, diodes and trimpot VR1, taking care with the positioning of ZD1 and ZD2. The ICs can be installed next, taking care with their orientation. The LM393 is placed adjacent to Q1.

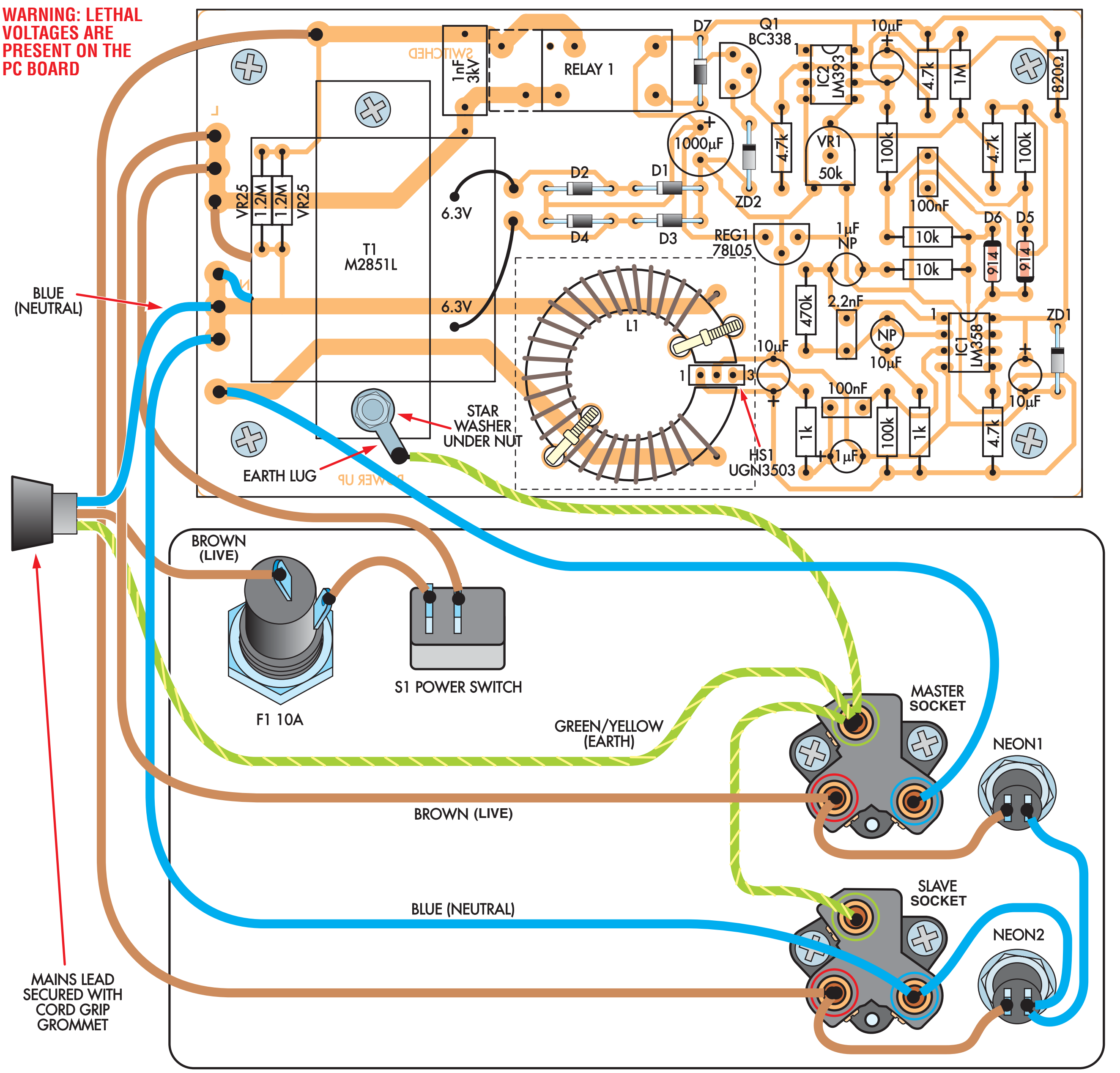
When installing transistor Q1 and the 78L05 regulator, take care that you don't get them confused; they look the same!

WARNING: MAINS VOLTAGES!

Note that this circuit is connected to the 240V AC mains supply and is potentially lethal. While most of the electronics circuitry is isolated from the mains, it is possible that you could make contact with a live part. In particular, note that inductor L1, the two 1·2MΩ resistors, the 1nF 3kV capacitor, the relay contacts and the Neon indicators all operate at 240V AC.

Do not apply power to this circuit unless it is fully enclosed in a plastic case and DO NOT TOUCH ANY PART OF THE CIRCUIT when it is plugged into a mains outlet. Always remove the plug from the mains before working on the circuit or making any adjustments.

Finally, do not build this project unless you are completely familiar with mains wiring practices and techniques.



NOTES: 1. COVER COIL L1 AND HALL SENSOR HS1 WITH **PLASTIC** INSULATION (FOR DETAIL SEE SEPARATE DIAGRAM).
2. COVER MAINS CONNECTIONS TO FUSEHOLDER, POWER SWITCH S1 AND NEON LAMPS WITH HEATSHRINK INSULATION SLEEVING.

Fig.3: follow this wiring diagram exactly to build the PowerUp. In particular, take care to ensure that all parts are oriented correctly and that the mains wiring is installed in a professional manner.

The capacitors can be installed next. Table 1 shows the codes on the MKT and ceramic types. **Make sure that the leads of the 3kV ceramic capacitor are covered with 5mm long insulating sleeving, before inserting it into the PC board.**

The electrolytic capacitors must be oriented with the polarity as shown, except for the two non-polarised (NP) types which can be mounted either way around. The relay is mounted next. We have provided PCB holes for different relays.

Making the toroidal inductor

As noted above, the toroid inductor (L1) is slotted to take the Hall sensor. Cutting a 2mm slot in a ferrite toroid is almost impossible because the material is so brittle but the specified powdered iron toroid is quite easy to cut with a hacksaw.

Clamp the toroid lightly in a vice; if you over-tighten the vice, it is likely to crack the core. After you have cut through one side of the toroid, you will need to enlarge the slot to about 2mm with a small file. Just make it sufficiently wide so that the Hall sensor can easily slide into the slot.

Now wind 42 turns of 1mm diameter enamelled copper wire onto the toroid and strip the insulation from the wire ends. That done, place this assembly

Table 1: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0·1µF	100n	104
2·2nF	(0·0022µF)	2n2	222
1nF	(0·001µF)	1n0	102

in position on the PC board with the slot directly over the position for the Hall sensor (see Fig.3). Finally, solder the wires in position and secure the inductor with cable ties.

You can now insert and solder in the Hall sensor, taking care with its orientation. The correct position is with the sensor body centrally located in the toroid slot.

Working on the case

The first step here is to drill out and file the hole in the end of the case for the cordgrip grommet. This hole must be a tight fit to make sure that it securely anchors the mains cord.

Next, mark out and drill the front panel for the mains outlets, switch, Neon indicators and fuseholder. If there is not room for two mains sockets on the front panel (sockets for different countries vary in size) either use IEC sockets or hard wire a distribution panel to the unit in place of the slave socket.

Note that the fuseholder must be a safety type, as specified in the parts list. Do not use a standard fuseholder.

The PC board can now be mounted in position. Once it's in, you can complete the wiring as shown in Fig.3.

Note that all mains wiring must be run in 7·5A 250V AC-wire. The earth connections are soldered or crimped to the solder lugs using green/yellow mains wire and secured to the transformer case using an M3 x 10mm metal screw, nut and star washer.

Parts List

1 PC board, code 557, 79 x 140mm available from the *EPE PCB Service*
1 plastic case, 165 x 85 x 55mm
2 chassis-mount mains sockets (see text)
1 12·6V 150mA mains transformer
1 10A 250V AC SPST (or SPDT) relay
1 6A SPST 250V AC mini mains rocker switch
2 250V AC Neon indicators
1 M205 panel-mount safety fuse holder (F1)
1 M205 10A fuse
1 7·5A mains cord and 3-pin plug
1 ring type crimp lug for 1·5-2·5mm diameter wire
1 70 x 70mm piece of plastic insulating material
1 powdered iron toroidal core 33mm OD x 20 ID x 10mm (Neosid 17-742-22; or similar)
1 50kΩ horizontal trimpot (coded 503) (VR1)
2 M3 x 10mm screws
2 M3 nuts
2 3mm star washers
1 2m length of 1mm enamelled copper wire
1 400mm length of 7·5A Brown 250V AC-rated wire
1 400mm length of 7·5A Blue 250V AC-rated wire
10 100mm long cable ties
10 PC stakes
1 80mm length of 3mm diameter heatshrink sleeving for mains to PC stake connections
1 40mm length of 6mm diameter heatshrink sleeving for switch terminals
1 100mm length of 13mm diameter heatshrink sleeving for fuseholder and Neon indicators

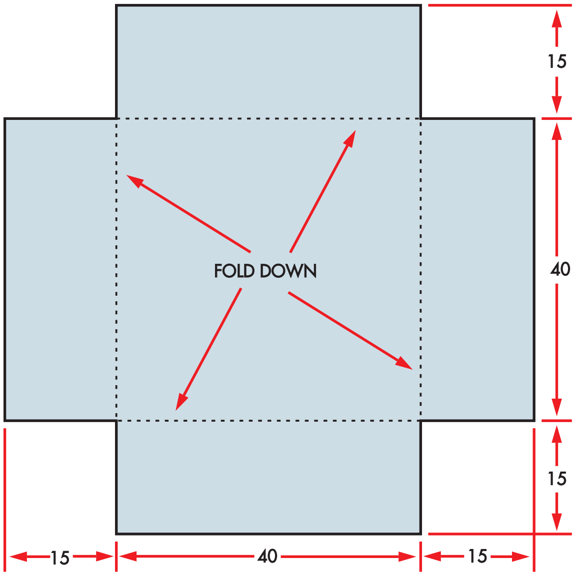
Semiconductors
1 LM358 dual op amp (IC1)
1 LM393 dual comparator (IC2)
1 UGN3503 Hall sensor (HS1)
1 78L05 3-terminal regulator (REG1)
1 BC338 NPN transistor (Q1)
1 12V 1W Zener diode (ZD1)
1 3·3V 1W Zener diode (ZD2)
5 1N4004 1A diodes (D1-D4,D7)
2 1N914 diodes (D5,D6)

Capacitors
1 1000µF 25V electrolytic
3 10µF 16V electrolytic
1 10µF 50V NP (non-polarised) electrolytic
1 1µF 16V electrolytic
1 1µF 50V NP (non-polarised) electrolytic
2 100nF (0·1µF) MKT polyester
1 2·2nF (0·0022µF) MKT polyester
1 1nF (0·001µF) 3kV ceramic

Resistors (1%, 0·25W)
2 1·2MΩ Philips VR25 (don't substitute)
1 1MΩ
1 470kΩ
3 100kΩ
2 10kΩ
4 4·7kΩ
2 1kΩ
1 820Ω

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	1·2MΩ (VR25)	brown red green yellow	N/A
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	4	4·7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	820Ω	grey red brown brown	grey red black black brown



PLASTIC INSULATION COVER FOR L1

Fig.4: this diagram shows how to make the plastic insulation cover that fits over coil L1.

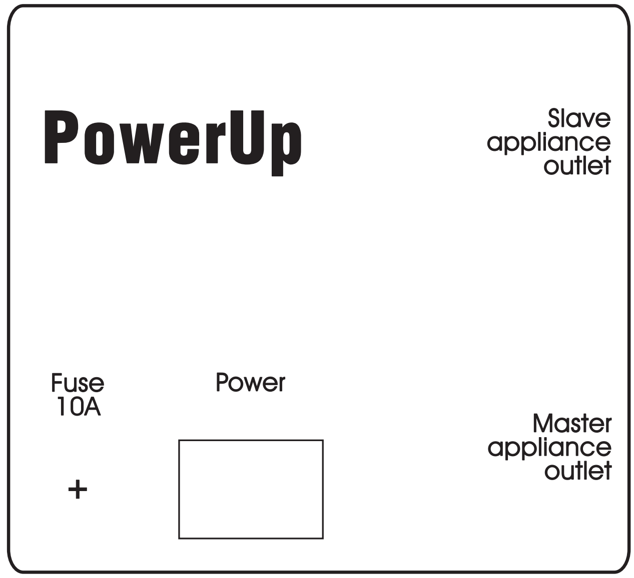


Fig.5: this full-size front-panel artwork can be used to mark the mounting positions for the fuseholder and the Power switch.

Specifications

Power level to switch slave	1 to 25W adjustable
Maximum load (master and slave GPO)	6A or 1440W (set by S1)
Standby current	18.5mA

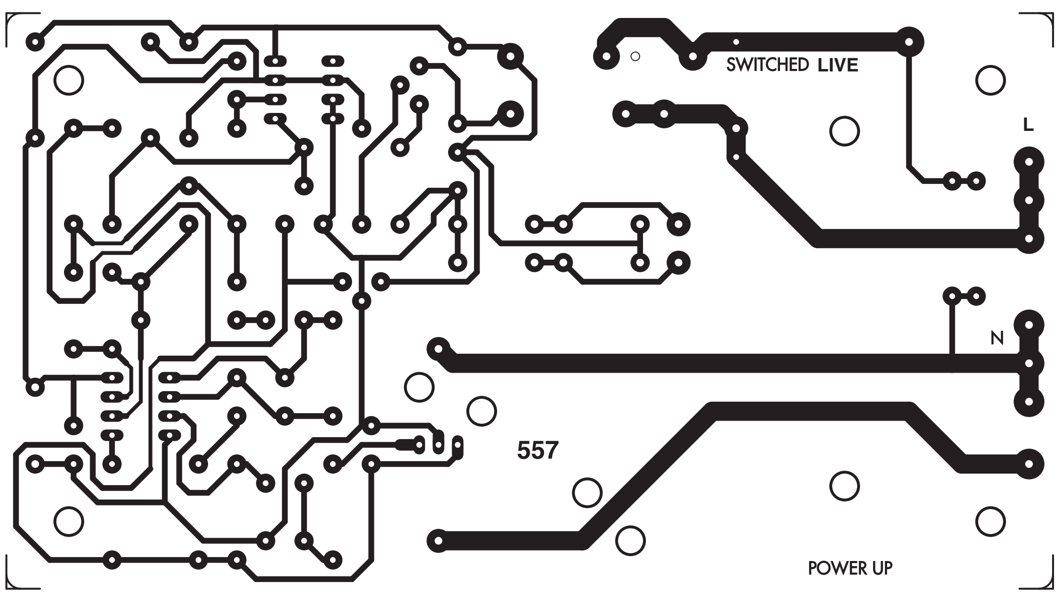
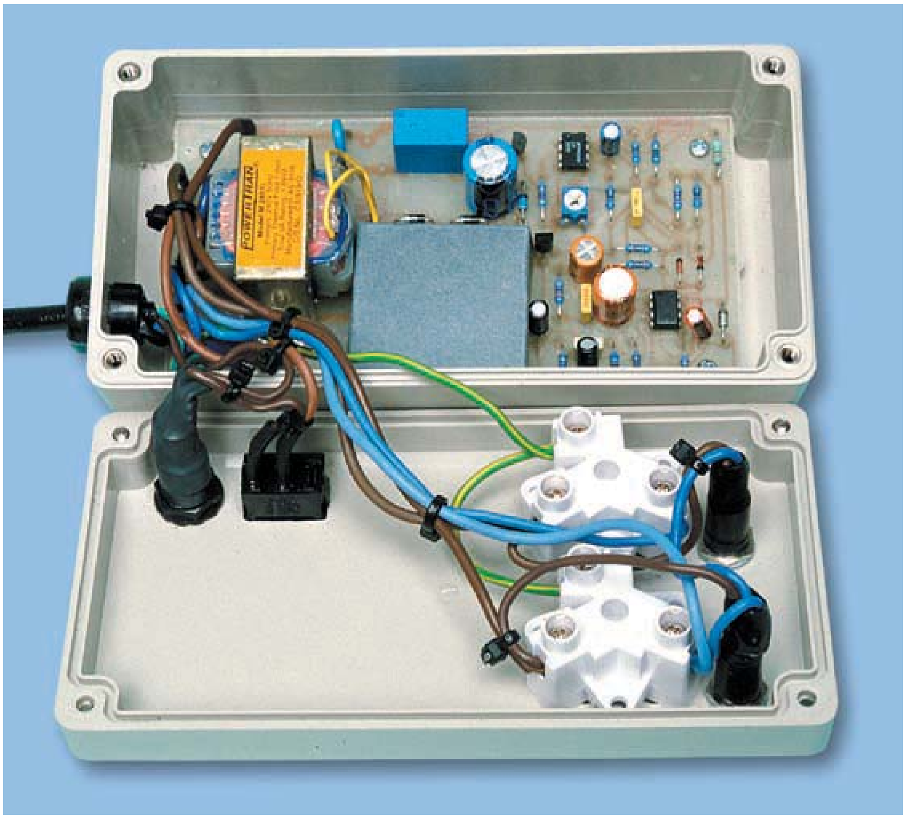


Fig.6: check your PC board against this full size etching pattern before installing any of the parts.



Use mains rated cable for all mains connections and bind the wires with cable ties to prevent them coming adrift. Note that all exposed mains connections must be covered with heatshrink tubing.

Make sure the transformer case is indeed earthed by measuring with a multimeter for a low ohm reading between earth and the transformer metal body. It may be necessary to scrape the lacquer coating off the transformer mounting foot to allow a good contact. Secure the other side of the transformer using an M3 x 10mm screw, star washer and nut.

Use heatshrink sleeving over any bare terminals. You should also tie the wires with cable ties to prevent them breaking and coming loose from their terminations. Make sure that the mains cord is securely anchored to the case with the cord grip grommet.

Inductor L1 has 240V AC flowing through it and to improve safety, this is covered with a plastic cover folded from a 70 x 70mm square piece of the material. Cut out 15mm squares on each corner and fold down. Fig.4 shows the details.

The cover sits over the toroid inductor and its connections to the PC board. This can be secured to the PC board with some silicone sealant.

Adjusting VR1

Trimpot VR1 is initially set to the midpoint. Once that's done, fit the lid, plug in the appliance to be used as the master (computer, stereo amplifier or whatever) and apply power.

Now turn on the master appliance. If Neon 2 does not light, you will need to disconnect the power and adjust VR1 – ie, turn it clockwise by a small amount. **Note: this should be done with the PowerUp's power cord disconnected from the mains wall socket (see warning panel).** You then redo the test and repeat the procedure again, as necessary.

Preset VR1 is adjusted correctly when Neon 2 is on when the master appliance is switched on and off when the master appliance is switched off. If the Neon is always alight, adjust VR1 further anticlockwise.

Troubleshooting

If the circuit does not work, switch off power and unplug the unit from the mains. Then check your work for correct wiring and parts placement.

You can check the supply voltages for each IC using mains-rated probes on your multimeter but take care not to touch any part of the circuit with your hands. IC1 should have 12V between pins 4 & 8, while IC2 should have about 15V or 16V between pins 4 & 8. The output from REG1 should be 5V. ***EPE***

EPE Tutorial Series

TEACH-IN 2006

Part Five – Introducing Magnetism and Inductance, Introducing Inductors, Transformers, Rectifiers and Voltage Regulation

MIKE TOOLEY BA

Our Teach-In 2006 series provides a broad-based introduction to electronics for the complete newcomer. The series also provides the more experienced reader with an opportunity to "brush up" on topics which may be less familiar. This month we investigate the theory that underpins inductors, transformers and power supplies.

Magnetism

Magnetism is an effect created by moving the elementary atomic particles in certain materials such as iron, nickel and cobalt. Iron has outstanding magnetic properties and materials that behave magnetically, in a similar manner to iron, are known as *ferromagnetic materials*. Such materials experience forces that act on them when placed near a magnet.

The atoms within these materials group in such a way that they produce tiny individual magnets with their own *North* and *South* poles. When subject to the influence of a magnet or when an electric current is passed through a coil surrounding them, these individual tiny magnets line up and the material as a whole exhibits magnetic properties.

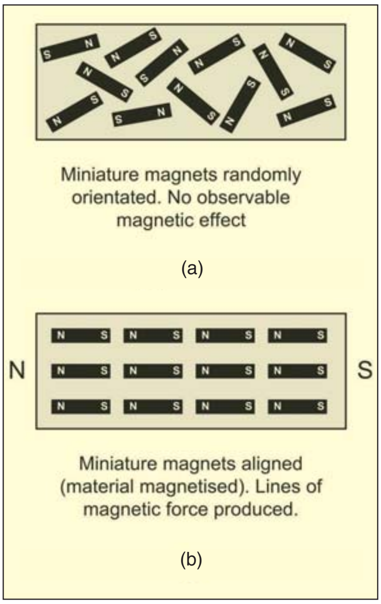


Fig.5.1. The behaviour of ferromagnetic materials

A ferromagnetic material that has not been influenced by the forces generated from another magnet is shown in Fig. 5.1a. In this case, the miniature magnets are oriented in a random manner. Once the material is subject to the influence of another magnet, then these miniature magnets line up, as shown in Fig. 5.1b, and the material itself becomes magnetic with its own North and South poles.

The space surrounding the magnet (in which the magnet exerts an influence on other magnetic materials) becomes filled with lines of magnetic flux which travel from North to South (indicating the movement of a free North pole).

Electromagnetism

Whenever an electric current flows in a conductor a magnetic field is set up around the conductor in the form of a series of concentric circles, as shown in Fig.5.2.

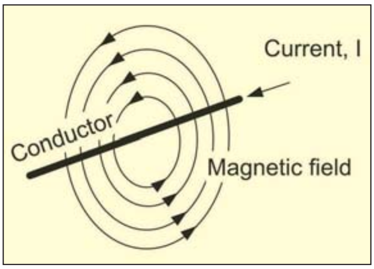


Fig.5.2. The magnetic field around a straight conductor

The field is present along the whole length of the conductor and is strongest nearest to the conductor. In order to concentrate and intensify the magnetic flux, the conductor may be wound into a coil or solenoid as shown in Fig. 5.3. It is important to note that the magnetic field around a solenoid is similar to that which surrounds a permanent magnet, as shown in Fig. 5.3.

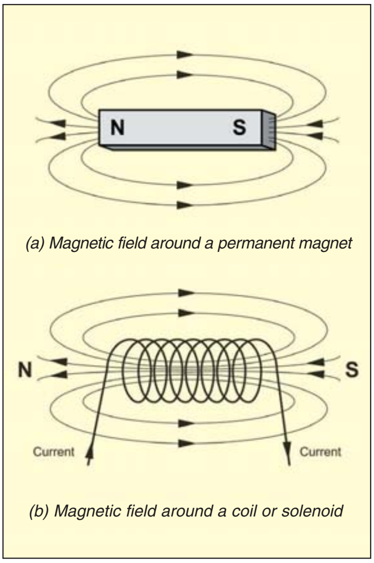


Fig.5.3. Magnetic field surrounding a permanent magnet and a solenoid

Check Point 5.1

Whenever an electric current flows in a conductor a magnetic field is set up in the space surrounding the conductor. The field spreads out around the conductor in concentric circles with the greatest density of magnetic flux nearest to the conductor.

The solenoid that we have just met has an important property that is known as *inductance* (or, more correctly *self-inductance*). This property results from the fact that a changing current (i.e. a current that doesn't remain constant) produces a changing magnetic flux in the space surrounding

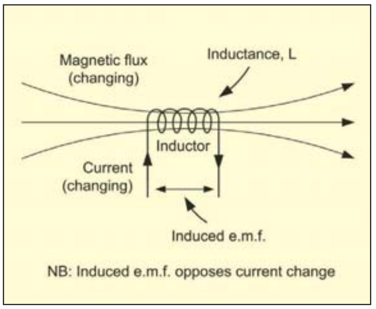


Fig.5.4. Induced e.m.f.

the solenoid. This, in turn, results in a small electromotive force (or e.m.f.) appearing across the terminals of the solenoid.

This induced e.m.f. is directly proportional to the rate at which the current changes (see Fig. 5.4). In other words, the faster the current changes the greater the induced voltage. Furthermore, because the induced e.m.f. acts in opposition to the current change that creates it, induced e.m.f. is sometimes referred to as *back e.m.f.*

Check Point 5.2

Induced e.m.f. tends to oppose any change of current and because of this we often refer to it as a *back e.m.f.*

The relationship between inductance, L, and induced e.m.f., e, is given by:

$$e = -L\frac{di}{dt}$$

where L is the self-inductance, $\frac{di}{dt}$ is the rate of change of current and the minus sign indicates the polarity of the generated e.m.f. (recall that this opposes the change that creates it).

The unit of inductance is the Henry (H) and a coil is said to have an inductance of 1H if a voltage of 1V is induced across it when a current changing at the rate of 1A/s is flowing in it.

Example 5.1

A coil has a self-inductance of 10H and is subject to a current that changes at a rate of 4A/s. What e.m.f. is produced?

Now $e = -L\frac{di}{dt}$ and hence:

$$e = -10 \times 4 = -40V$$

Note the minus sign. This tells us that a back e.m.f. of 40V is produced.

Example 5.2

A current increases at a uniform rate from 2A to 6A in a time of 250ms. If this current is applied to an inductor determine the value of inductance if a back e.m.f. of 15V is produced across its terminals.

Now $e = -L\frac{di}{dt}$ and hence $L = -e\frac{dt}{di}$

Thus:

$$L = -(-15) \times \frac{250 \times 10^{-3}}{(6-2)} = 15 \times 62{\cdot}5 \times 10^{-3}$$

$$= 937{\cdot}5 \times 10^{-3} = 0{\cdot}94H$$

Table 5.1. Comparison between electric and magnetic circuits

Electric circuit	Magnetic circuit
Electromotive force, e.m.f. = V	Magnetomotive force, m.m.f. = N × I
Resistance = R	Reluctance = S
Current = I	Flux = Φ
e.m.f. = current × resistance	m.m.f. = flux × reluctance
V = IR	NI = SΦ

Magnetic Circuits

Materials such as iron and steel possess considerably enhanced magnetic properties. Hence they are employed in applications where it is necessary to increase the flux density produced by an electric current. In effect, they allow us to concentrate and channel the electric flux into a closed magnetic circuit, as shown in Fig.5.5b.

In the circuit of Fig.5.5b the reluctance of the magnetic core is analogous to the resistance present in the electric circuit shown in Fig.5.5a and we can make comparisons as in Table 5.1:

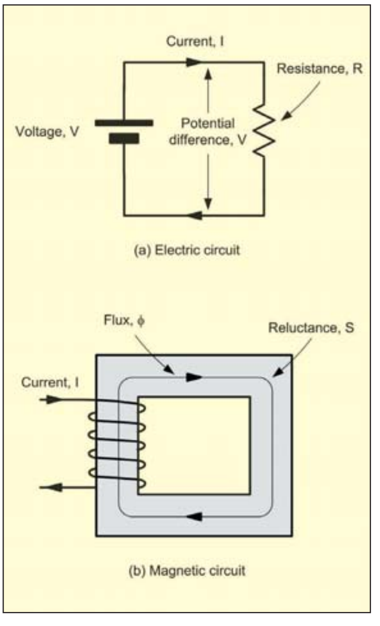


Fig.5.5. Comparison of (a) electric and (b) magnetic circuits

Reluctance and Permeability

The reluctance of a magnetic circuit is directly proportional to its length and inversely proportional to its cross-sectional area. The reluctance is also inversely proportional to the absolute permeability of the magnetic material.

Thus:

$$S = \frac{l}{\mu A}$$

where S is the reluctance of the magnetic path, l is the length of the path (in m), A is the cross-sectional area of the path (in m^2), and μ is the absolute permeability of the magnetic material.

Now the absolute permeability of a magnetic material is the product of the permeability of free space (μ_0) and the relative permeability of the magnetic medium (μ_r).

Thus:

$$\mu = \mu_0 \times \mu_r$$

and:

$$S = \frac{l}{\mu_o \mu_r A}$$

One way of thinking about permeability is that it is a measure of a magnetic medium's ability to support magnetic flux when subjected to a magnetising force. Thus absolute permeability μ, is given by:

$$\mu = \frac{B}{H}$$

where B is the flux density (T) and H is the magnetising force (A/m).

The term "magnetising force" needs a little explanation. We have already said that, in order to generate a magnetic flux we need to have a current flowing in a conductor and that we can increase the field produced by winding the conductor into a coil which has a number of turns of wire.

The product of the number of turns, N, and the current flowing, I, is known as *magnetomotive force*, or m.m.f (look back at the comparison table of electric and magnetic circuits if this is still difficult to understand). The magnetising force, H, is the m.m.f. (i.e. $N \times I$) divided by the length of the magnetic path, l. Thus:

$$H = \frac{m.m.f.}{l} = \frac{NI}{l}$$

where H is the magnetising force (in A/m), N is the number of turns, I is the current (in A), and l is the length of the magnetic path (in m).

Check Point 5.3

The magnetomotive force (m.m.f.) produced in a coil can be determined from the product of the number of turns, N, and the current flowing, I. The units of m.m.f. are "Ampere-turns" or simply A (as "turns" strictly has no units). Magnetising force, on the other hand, is determined from the m.m.f. divided by the length of the magnetic circuit, l, and its units are "Ampere turns per metre" or simply A/m.

Energy Storage

The energy stored in an inductor is proportional to the product of the inductance and the square of the current flowing in it. Thus:

$$W = 0{\cdot}5\, L\, I^2$$

where W is the energy (in J), L is the inductance (in H), and I is the current (in A).

Example 5.3

A current of 2A flows in an inductor of 10H. Determine the energy stored.

Solution

Now $W = 0{\cdot}5\ L\ I^2 = 0{\cdot}5 \times 10 \times 2^2 = 20J$

Factors Determining Inductance

The inductance of an inductor depends upon the physical dimensions of the inductor (e.g. the length and diameter of the winding), the number of turns, and the permeability of the material of the core. The inductance of an inductor is given by:

$$L = \frac{\mu_o \mu_r n^2 A}{l}$$

where L is the inductance (in H), μ_0 is the permeability of free space ($12{\cdot}57 \times 10^{-7}$ H/m), μ_r is the relative permeability of the magnetic core, l is the length of the core (in m), n is the number of turns, and A is the cross-sectional area of the core (in m^2).

Example 5.3

An inductor of 200mH is required. If a closed magnetic core of length 20cm, cross sectional area $15cm^2$ and relative permeability 400 is available, determine the number of turns required.

Solution

Now $L = \frac{\mu_o \mu_r n^2 A}{l}$ and hence $n = \sqrt{\frac{Ll}{\mu_o \mu_r A}}$

Thus

$$n = \sqrt{\frac{Ll}{\mu_o \mu_r A}} = \sqrt{\frac{200\times10^{-3}\times20\times10^{-2}}{12.57\times10^{-7}\times400\times15\times10^{-4}}}$$

$$= \sqrt{\frac{4\times10^{-2}}{75420\times10^{-11}}} = \sqrt{53036} = 230$$

Hence the inductor requires 230 turns of wire.

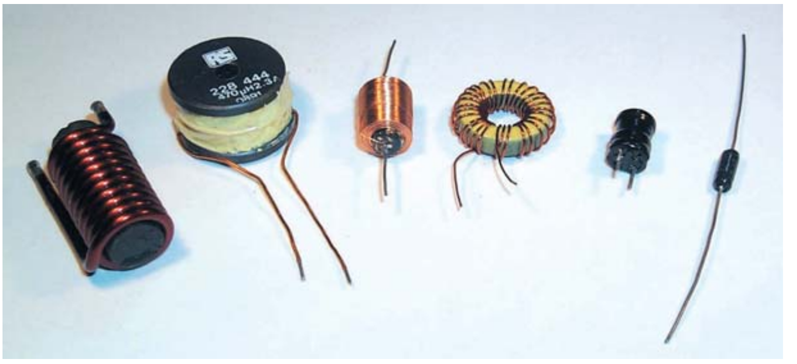


Photo 5.1. Various inductors with values ranging from 10µH to 1mH at current ratings from 100mA to 25A

Now see if you can answer the following questions on inductors:

Questions 5.1

Q5.1. An inductor comprises 150 turns of wire wound on a closed magnetic core of length 16cm, cross sectional area $1cm^2$ and relative permeability 600. Determine the inductance.

Q5.2. A current changing at the rate of 0·5A per second is flowing through a 500mH inductor. What voltage will be produced?

Q5.3. A 1H inductor is required to store 500mJ of energy. What current should be flowing in the inductor?

Introducing Inductors

Inductor specifications normally include the value of inductance (expressed in H, mH, µH, or nH), the current rating (i.e. the maximum current which can be continuously applied to the inductor under a given set of conditions), and the accuracy or tolerance (quoted as the maximum permissible percentage deviation from the marked value). Other considerations may include the temperature coefficient of the inductance (usually expressed in parts per million, p.p.m., per unit temperature change), the stability of the inductor, the DC resistance of the coil windings (ideally zero), the Q-factor (quality factor) of the coil, and the recommended working frequency range.

The following table summarises the properties of commonly available types of inductor.

Several manufacturers supply fixed and variable inductors for operation at high and radio frequencies. Fixed components are generally available in the E6 series between 1µH and 10mH. Variable components have ferrite dust cores that can be adjusted in order to obtain a precise value of inductance.

The larger inductance values generally exhibit a larger DC resistance due to the greater number of turns and relatively small diameter of wire used in their construction.

At medium and low frequencies inductors are often manufactured using one of a range of ferrite pot cores. The core material of these inductors is commonly available in several types and the complete pot core assembly comprises a matched pair of core halves, a single-section bobbin, a pair of retaining clips, and a core adjuster. Effectively, the coil winding is totally enclosed in a high

Table 5.2. Inductor types

		Single-layer open		Multi-layer open		Multi-layer pot cored	Multi-layer iron cored
Characteristics	Core material	Air	Ferrite	Air	Ferrite	Ferrite	Iron
	Capacitance range	50nH to 10µH	1µH to 100µH	5µH to 500µH	10µH to 1mH	1mH to 100mH	20mH to 20H
	Typical Tolerance	±10%	±10%	±10%	±10%	±10%	±10%
	Typical current rating	0·1A	0·1A	0·2A	0·5A	0·5A	0·2A
	Typical DC resistance	0·05Ω to 1Ω	0·1Ω to 10Ω	1Ω to 20Ω	2Ω to 100Ω	2Ω to 100Ω	10Ω to 400Ω
	Typical Q-factor	60	80	100	80	40	20
	Typical frequency range	5MHz to 500MHz	1MHz to 500MHz	200kHz to 20MHz	100kHz to 10MHz	1kHz to 1MHz	50Hz to 1kHz
	Typical applications	Tuned circuits		Filters and HF transformers		LF and MF chokes and transformers	LF chokes and transformers

permeability ferrite pot. Typical values of inductance for these components range between 100μH and 100mH with a typical saturation flux density of 250mT.

Inductance values of iron cored inductors are very much dependent upon the applied direct current and tend to fall rapidly as the value of applied direct current increases and saturation is approached. Maximum current ratings for larger inductors are related to operating temperatures and should be de-rated when high ambient temperatures are expected. Where reliability is important, inductors should be operated at well below their nominal maximum current ratings.

Finally, ferrite (a high permeability non-conductive magnetic material) is often used as the core material for inductors used in high-frequency filters and as broadband transformers at frequencies of up to 30MHz. At these frequencies, inductors can be realised very easily using these cores with just a few turns of wire.

Check Point 5.4

The specifications for an inductor usually include the value of inductance (expressed in H, mH or μH), the current rating (quoted as the maximum permissible percentage deviation from the marked value), the DC resistance (this is the resistance of the coil windings measured in ohms (Ω)).

The Q-factor and frequency range are also important considerations for certain types of inductor.

Introducing Transformers

It's now time to introduce another useful electronic component, the *transformer*. A selection of transformers is shown in Photo 5.2.

The principle of the transformer is illustrated in Fig.5.6. The primary (input) and secondary (output) coil windings are wound on a common low-reluctance magnetic core consisting of a number of steel laminations. All of the alternating flux generated by the primary winding is therefore coupled into the secondary winding (very little flux escapes due to leakage).

A sinusoidal current flowing in the primary winding will produce a sinusoidal flux within the transformer core which will link with the secondary winding and induce an alternating voltage in it. The basic transformer arrangement shown in Fig.5.6 is shown in symbolic (circuit) form in Fig.5.7.

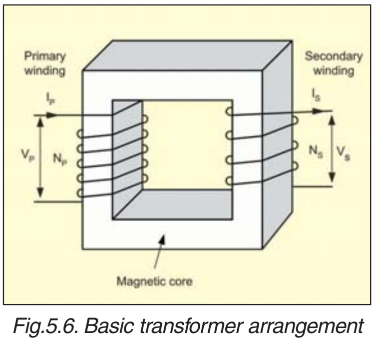


Fig.5.6. Basic transformer arrangement

Photo 5.2. Various types of transformers

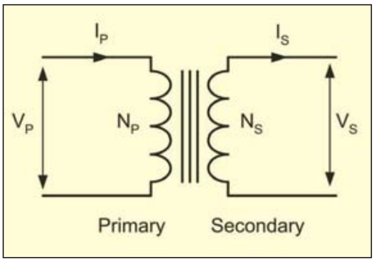


Fig.5.7. Voltage, current and turns

Since the same magnetic flux appears in both the primary and secondary windings we can infer the following relationship between the primary and secondary voltages and turns:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

Furthermore, assuming that no power is lost in the transformer (i.e. as long as the primary and secondary powers are the same) we can conclude that:

$$\frac{I_S}{I_P} = \frac{N_P}{N_S}$$

The ratio of primary turns to secondary turns (N_P/N_S) is known as the *turns ratio*. Note also that, since the ratio of primary voltage to primary turns is the same as the ratio of secondary turns to secondary voltage, we can conclude that, for a particular transformer:

$$\text{Turns-per-volt (t.p.v.)} = \frac{V_P}{N_P} = \frac{V_S}{N_S}$$

The turns-per-volt rating can be quite useful when it comes to designing transformers with multiple secondary windings.

Example 5.4

A transformer has 2,000 primary turns and 120 secondary turns. If the primary is connected to a 220V AC mains supply, determine the secondary voltage.

Since $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ we can conclude that:

$$V_S = \frac{V_P N_S}{N_P} = \frac{220 \times 120}{2000} = 13{\cdot}2V$$

Example 5.5

A transformer has 1,200 primary turns and is designed to operated with a 110V AC supply. If the transformer is required to produce an output of 10V, determine the number of secondary turns required.

Since $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ we can conclude that:

$$N_S = \frac{N_P V_S}{V_P} = \frac{1200 \times 10}{110} = 109\text{turns}$$

Transformers provide us with a means of coupling AC power from one circuit to another without a direct connection between the two. A further advantage of transformers is that voltage may be stepped-up (secondary voltage *greater* than primary voltage) or stepped-down (secondary voltage *less* than primary voltage).

Since no increase in power is possible (like resistors, capacitors and inductors, transformers are passive components) an increase in secondary voltage can only be achieved at the expense of a corresponding reduction in secondary current, and vice versa (in fact, the secondary power will be very slightly less than the primary power due to losses within the transformer).

The specifications for a transformer usually include the rated primary and secondary voltages and currents, the required power rating (i.e. the rated power, usually expressed in Volt-Amperes,

VA) which can be continuously delivered by the transformer under a given set of conditions), the frequency range for the component (usually stated as upper and lower working frequency limits), and the per-unit regulation of a transformer.

This last specification is a measure of the ability of a transformer to maintain its rated output when a load is imposed on it.

Questions 5.2

Q5.4. A transformer has 880 primary turns and is designed to operate with a 220V AC supply. How many secondary turns will be required to produce an output of 18V?

Q5.5. A transformer has 1,200 primary turns and 200 secondary turns. The transformer delivers a secondary current of 4A into a 10Ω load resistor. Assuming that no power is lost in the transformer, determine the primary voltage and current.

Check Point 5.4

Transformers provide a convenient means of coupling AC power from one circuit to another without having to make a direct connection. The power is coupled through the magnetic flux that links the primary and secondary windings. The ratio of primary to secondary turns determines the ratio of input (primary) to output (secondary) voltage and so a transformer can be used to step-up or step-down an AC voltage.

Rectifiers

Semiconductor diodes are commonly used to convert alternating current (AC) to direct current (DC), in which case they are referred to as *rectifiers*. The simplest form of rectifier circuit makes use of a single diode and, since it operates on only either positive or negative half-cycles of the supply, it is known as a *half-wave rectifier*. Fig.5.8 shows a simple half-wave rectifier circuit.

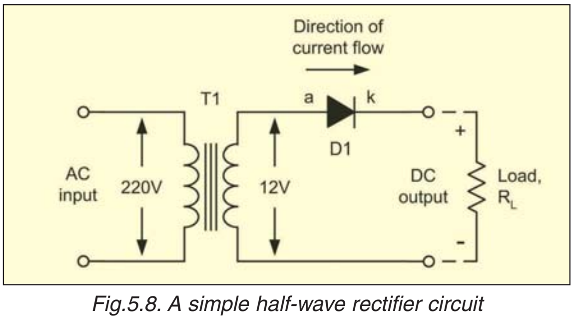


Fig.5.8. A simple half-wave rectifier circuit

The AC supply at 220V is applied to the primary of a step-down transformer (T1). The secondary of T1 steps down the 220V 50Hz supply to 12V RMS (the turns ratio of T1 will thus be 220/12 or 18.3:1). Diode D1 will only allow the current to flow in the direction shown (i.e. from anode to cathode). Diode D1 will be forward biased during each positive half-cycle and will effectively behave like a closed switch, as shown in Fig.5.9a.

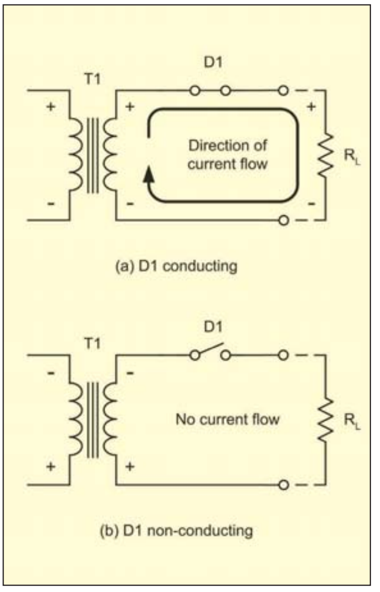


Fig.5.9. Switching action of the diode in the half-wave rectifier (a) D1 forward biased (b) D1 reverse biased

When the circuit current tries to flow in the opposite direction, the voltage bias across the diode will be reversed, causing the diode to act like an open switch, as shown in Fig.5.9b.

The switching action of D1 results in a pulsating output voltage, which is developed across the load resistor (R_L). Since the supply is at 50Hz, the pulses of voltage developed across R_L will also be at 50Hz even if only half the AC cycle is present.

During the positive half-cycle, the diode will drop the 0·6V forward threshold voltage normally associated with silicon diodes. However, during the negative half-cycle the peak AC voltage will be dropped across D1 when it is reverse biased. This is an important consideration when selecting a diode for a particular application. Assuming that the secondary of T1 provides 12V RMS, the peak voltage output from the transformer's secondary winding will be given by:

$$V_{pk} = 1{\cdot}414 \times V_{RMS} = 1{\cdot}414 \times 12V = 16{\cdot}97V$$

The peak voltage applied to D1 will thus be approximately 17V. The negative half-cycles are blocked by D1 and thus only the positive half-cycles appear across R_L. Note, however, that the actual peak voltage across R_L will be the 16·97V positive peak being supplied from the secondary on T1, minus the 0·6V forward threshold voltage dropped by D1. In other words, positive half-cycle pulses having a peak amplitude of *approximately* 17V will appear across R_L. The waveforms of voltages in the simple half-wave power supply are shown in Fig.5.10.

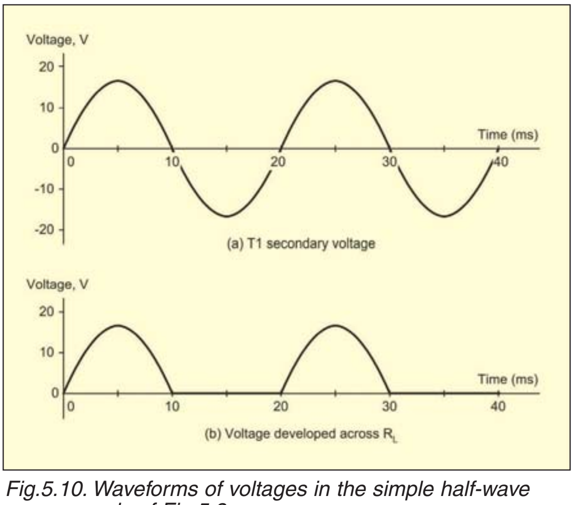


Fig.5.10. Waveforms of voltages in the simple half-wave power supply of Fig.5.8

The circuit Fig.5.11 shows a considerable improvement to the simple rectifier circuit in Fig.5.8. The capacitor, C1, has been added to ensure that the output voltage remains at, or near, the peak voltage even when the diode is not conducting.

When the primary voltage is first applied to transformer T1, the first positive half-cycle output from the secondary will charge C1 to the peak value seen across R_L. Hence C1 charges to *approximately* 17V at the peak of the positive half-cycle.

Because C1 and R_L are in parallel, the voltage across R_L will be the same as that developed across C1 (see Fig.5.12).

Charge and Discharge Timing Constant

The time required for capacitor C1 to charge to the maximum (peak) level is determined by the charging circuit time constant (the series resistance multiplied by the capacitance value). In this circuit, the series resistance comprises the secondary winding resistance together with the forward resistance of the diode and the (minimal) resistance of the wiring and connections.

The time required for C1 to discharge is, in contrast, very much greater. The discharge time constant is determined by the capacitance value and the load resistance, R_L. In practice, R_L is very much larger than the resistance of the secondary circuit and hence C1 takes an

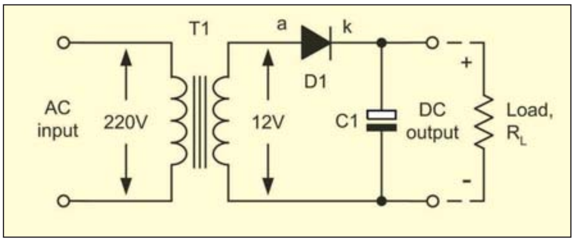


Fig.5.11. Effect of adding a reservoir capacitor to the output of the simple half-wave power supply

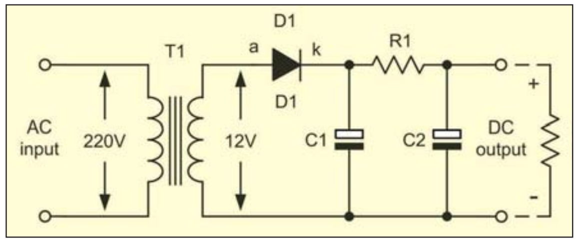


Fig.5.13. Half-wave power supply with reservoir capacitor and smoothing filter

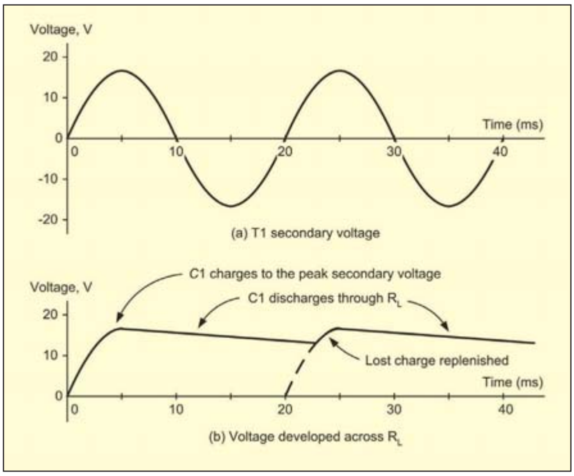


Fig.5.12. Waveforms of voltages in the half-wave power supply with reservior capacitor, Fig.5.11.

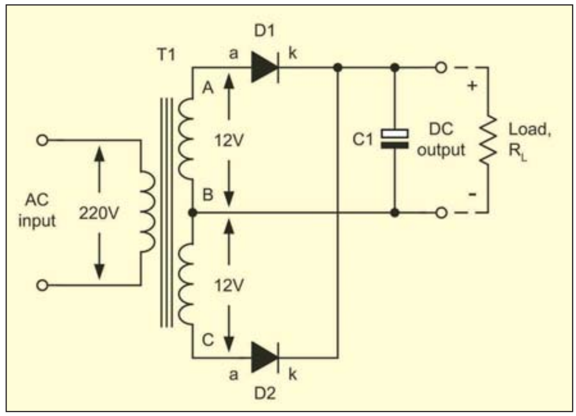


Fig.5.14. A simple bi-phase rectifier circuit with reservoir capacitor

appreciable time to discharge. During this time, diode D1 will be reverse biased and will thus be held in its non-conducting state. As a consequence, the only discharge path for C1 is through R_L.

Capacitor C1 is referred to as a *reservoir capacitor*. It stores charge during the positive half-cycles of secondary voltage and releases it during the negative half-cycles. The circuit shown in Fig.5.11 is thus able to maintain a reasonably constant output voltage across R_L. Even so, C1 will discharge by a small amount during the negative half-cycle periods from the transformer secondary.

The waveforms in Fig.5.12 show the secondary voltage together with the voltage developed across R_L with and without C1 present. This gives rise to a small variation in the DC output voltage (known as *ripple*).

Since ripple is undesirable we must take additional precautions to reduce it. One obvious method of reducing the amplitude of the ripple is that of simply increasing the discharge time constant. This can be achieved either by increasing the value of C1 or by increasing the resistance value of R_L. In practice, however, the latter is not really an option because R_L is the effective resistance of the circuit being supplied and we don't usually have the ability to change it!

Increasing the value of C1 is a more practical alternative and very large capacitor values (often in excess of 1,000μF) are typical.

The circuit in Fig.5.13 shows a further refinement of the simple power supply. This circuit employs two additional components, R1 and C2, which act as a filter to remove the ripple.

Full-wave Rectifier

The half-wave rectifier circuit is relatively inefficient as conduction takes place only on alternate half-cycles. A better rectifier arrangement would make use of both positive and negative half-cycles. These *full-wave rectifier* circuits offer a considerable improvement over their half-wave counterparts. They are not only more efficient but are significantly less demanding in terms of the reservoir and smoothing components.

There are two basic forms of full-wave rectifier; the bi-phase type and the bridge rectifier type. A simple *bi-phase rectifier* circuit is shown in Fig.5.14. The AC supply at 220V is applied to the primary of a step-down transformer (T1). This has two identical secondary windings, each providing 12V RMS (the turns ratio of T1 will still be 220/12 or 18·3 for each secondary winding).

On positive half-cycles, point A will be positive with respect to point B. Similarly, point B will be positive with respect to point C. In this condition D1 will allow conduction (its anode will be positive with respect to its cathode) while D2 will not allow conduction (its anode will be negative with respect to its cathode). Thus D1 alone conducts on positive half-cycles.

On negative half-cycles, point C will be positive with respect to point B. Similarly, point B will be positive with respect to point A. In this condition D2 will allow conduction (its anode will be positive with respect to its cathode) while D1 will not allow conduction (its anode will be negative with respect to its cathode). Thus D2 alone conducts on negative half-cycles.

As with the half-wave rectifier, the switching action of the two diodes results in a pulsating output voltage being developed across the load resistor (R_L).

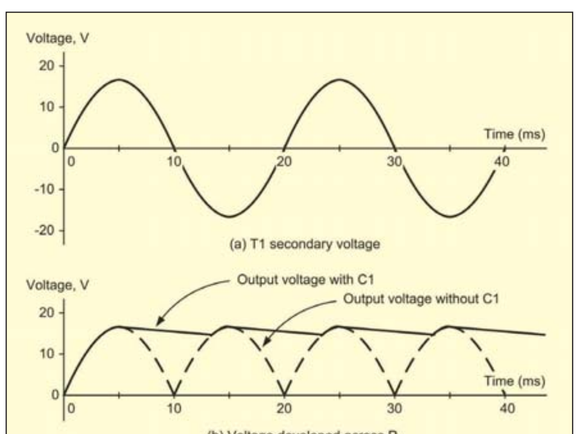


Fig.5.15. Waveforms of voltages in the bi-phase power supply with reservoir capacitor, Fig.5.14.

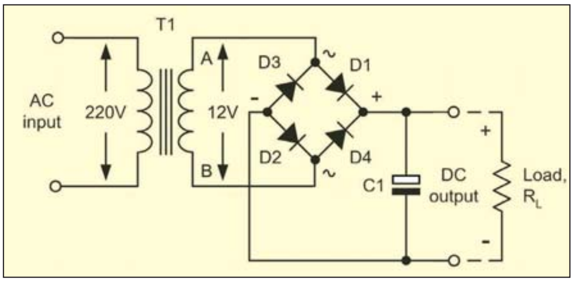


Fig.5.16. A full-wave rectifier circuit using a bridge rectifier

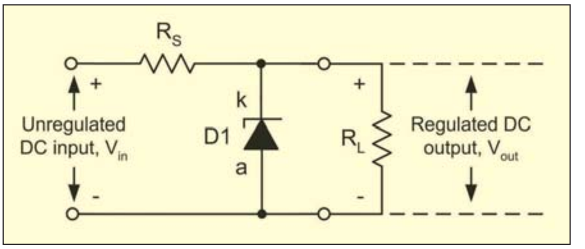


Fig.5.17. A simple Zener diode voltage regulator

However, unlike the half-wave circuit, the pulses of voltage developed across R_L will occur at a frequency of 100Hz (not 50Hz).

This doubling of the ripple frequency allows us to use smaller values of reservoir and smoothing capacitor to obtain the same degree of ripple reduction (recall that the reactance of a capacitor is reduced as frequency increases).

As before, the peak voltage produced by each of the secondary windings will be approximately 17V. The reservoir capacitor (C1) acts in exactly the same way as for the half-wave rectifier circuit that we met earlier, i.e. it charges to approximately 17V at the peak of the positive half-cycle and holds the voltage at this level when the diodes are in their non-conducting states. The waveforms of voltages in the bi-phase power supply with reservoir capacitor are shown in Fig.5.15.

Bridge Rectifier

An alternative to the use of the bi-phase circuit is that of using a four-diode *bridge rectifier* in which opposite pairs of diode conduct on alternate half-cycles. This arrangement avoids the need to have two separate secondary windings. A full-wave bridge rectifier arrangement is shown in Fig.5.16.

The 220V AC supply at 50Hz is applied to the primary of a step-down transformer (T1). As before, the secondary winding provides 12V RMS (approximately 17V peak) and has a turns ratio of 18·3:1. On positive half-cycles, point A will be positive with respect to point B. In this condition D1 and D2 will allow conduction while D3 and D4 will not allow conduction. Conversely, on negative half-cycles, point B will be positive with respect to point A. In this condition D3 and D4 will allow conduction while D1 and D2 will not allow conduction.

As with the bi-phase rectifier, the switching action of the two diodes results in a pulsating output voltage being developed across the load resistor (R_L). The peak output voltage is approximately 15·8V (i.e. 17V less the 2 × 0·6V forward threshold voltage of the two diodes).

The reservoir capacitor (C1) is again added to the circuit in order to ensure that the output voltage remains at, or near, the peak voltage even when the diodes are not conducting. This component operates in exactly the same way as for the bi-phase circuit, i.e. it charges to approximately 16V at the peak of the positive half-cycle and holds the voltage at this level when the diodes are in their non-conducting states. The voltage waveforms are similar to those that we met earlier for the bi-phase rectifier.

Voltage Regulation

In a practical power supply we usually need some means of maintaining the DC output voltage constant regardless of changes in the AC supply or the load current demanded from the supply. A simple *voltage regulator* is shown in Fig.5.17.

The series resistor, R_S is included to limit the Zener diode (D1) current to a safe value when the load is disconnected. When a load (R_L) is connected, the Zener current will fall as current is diverted into the load resistance (it is usual to allow a minimum current of 2mA to 5mA in order to ensure that the diode regulates).

The output voltage will remain at the Zener voltage (V_Z) until regulation fails at the point at which the potential divider formed by R_S and R_L produces an output voltage that is less than V_Z. The ratio of R_S to R_L is thus important.

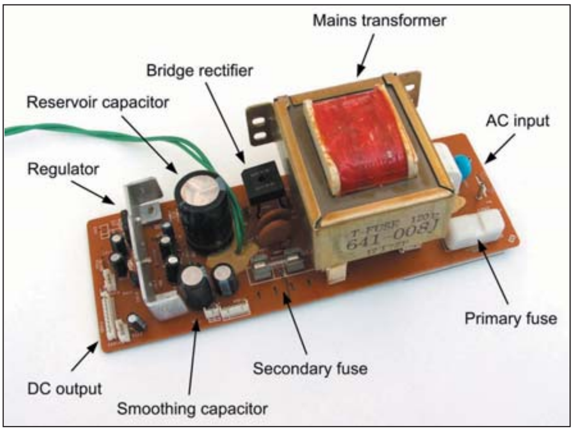


Fig.5.18. A complete power supply

Finally, a practical power supply is shown in Fig.5.18. This circuit uses a step-down transformer, bridge rectifier, reservoir capacitor and voltage regulator. It provides a smoothed and regulated DC output voltage of 18V at 2A.

Answers To Questions

Q5.1	10·6mH
Q5.2	–0·25V
Q5.3	1A
Q5.4	72 turns
Q5.5	240V, 0·67A

Next Month

In Part 6, next month, we shall be introducing transistors and investigating their use in amplifier circuits. In the meantime you might like to see how you get on with our on-line quiz for Part 5. You will find this at:

www.miketooley.info/teach-in/quiz5.htm

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

PREVIOUSLY we looked at using computer programs to design computer labels and front panel overlays. As pointed out in the earlier article, the range of free and low-cost drawing programs seems to be somewhat reduced from the large range that was on offer a few years ago.

To be more accurate, the range of good but free or cheap drawing programs has reduced. However, as explained previously, there are still some worthwhile candidates.

With traditional materials for graphic designers becoming harder to obtain, the computerised approach is becoming increasingly attractive. For most of us, results using a computer based approach are far better than those obtained using traditional methods.

Practicalities

Having obtained suitable software there is the minor matter of getting it to do something. In many ways the task is much the same whether a front panel design is produced using pencil and paper or a computer and printer. Either way, you have to produce a design that is functional as well as being neat and attractive. It is easy to come up with a design that looks impressive but is either impossible to make or difficult to use.

A design will be impossible to realise in practice unless great care is taken to ensure that there is space for everything to fit correctly. Most problems can be avoided by making careful measurements and drawing the layout accurately to scale. Any modern drawing program should enable scale drawings to be produced and printed out at actual size.

Make sure that the spacing of the controls leaves sufficient room for the control knobs. Remember that most types of control knob will be very difficult to use unless a reasonable gap is left between each one in a row of controls. Ideally there should be a gap of about 10mm between each control knob.

Fig.1. Producing a dummy front panel layout gives a good idea of what the finished project will look like

The classic mistake when designing a front panel layout is to only consider the front side of the panel, and leave insufficient space for a potentiometer, switch, or whatever. In many cases there will not be any chance of this occurring, because the control knobs on the front of the panel will be larger than the controls on the rear side. The small physical size of modern components helps in this respect, but some components are still relatively large. Take particular care when designing the front panel for a project that uses rotary switches or any other rotary control that is fairly large.

A good way of working out a layout is to have the case with the front panel facing upwards and then place the control knobs on it and try various layouts. The fixing nuts can be used to represent things like toggle switches, a washer can be used to represent something like a LED, and so on (Fig.1). With this method you get a good idea of what the finished project will look like, and it is easy to judge whether sufficient space is being allowed for each component. Having found a neat and practical layout, take some careful measurements and make an actual size drawing of the layout. Include things like the dimensions of cut-outs, the diameters of mounting holes, etc. This will make life much easier when you start work on the panel.

When producing a front panel layout I prefer to see it "in the flesh", but there is an alternative method available when using a drawing program. You can "cut to the chase" and produce the layout using the drawing program. Any drawing program should have a facility for producing symbols that can be added to a drawing and moved around easily. In this context the symbols are representations of things like control knobs and lights that are drawn accurately to scale, and they should also be reasonable likenesses of the real thing.

Using a 3D drawing program it is possible to produce a 3D representation of the finished gadget that can be viewed from any angle. In fact most commercial products start out as 3D models in a computer.

However, the 3D approach requires some fairly advanced software in order to do a good job. It also requires much more skill than 2D drawing and a lot more time to set up the program with suitable symbols.

Hobson's Choice

With some projects your choice of front panel layout will be strictly limited because the controls, sockets, LEDs, etc. will be mounted on the circuit board. The layout of the front panel is therefore already designed for you to a large extent. The spacing of the mounting holes in the front panel must accurately match up with the spacing of the controls on the circuit board or it will not be possible to fit the board assembly onto the front panel.

The article might include details of the distances between the front panel components, but if not it is just a matter of making some careful measurements. It has to be emphasised that accuracy is all-important with this type of thing. One or two quite small errors can make it impossible to fit the circuit board assembly on to the front panel.

Of course, where the original design has the controls, etc., mounted on the board it is not essential to do things this way. You can "do your own thing" and hard wire the front panel components to the circuit board. With complex projects this would have to be regarded as doing things the hard way, but with the more simple projects it gives greater versatility and could be a worthwhile approach. For beginners though, it is advisable to keep it simple and mount the front panel components on the circuit board.

A final and important point to keep in mind is that modern cases in general, and the plastic variety in particular, tend to have a variety of obstructions inside. In some cases these are essential items that are needed to help fix the two halves of the case together, or something of this nature. The obstructions are often intended to be mounting pillars for the circuit board, but they will not necessarily be of any use with the particular project you are building. Some cases have "mystery" obstructions that serve no apparent purpose and are probably part of the manufacturing process.

Any obstructions inside the case will be of little consequence if they are well away from the front panel, but it is quite common for some of them to be located close to the ends of the panel. This effectively produces a "no-go" area at each end of the front panel where large components cannot be accommodated, and with some cases there will not even be sufficient space for small sockets and switches. Unwanted mounting pillars and odd mouldings can be carefully cut or drilled away if they become a serious nuisance, but you just have to work the design around anything that is an essential part of the case.

Long and Short Of It

In general, a front panel layout will be neater if the controls, etc., are in one or two rows rather than liberally scattered all over the place. In theory, you can use any desired front panel layout if the controls, etc., are hard wired to the circuit board. In reality it is not always as simple as that, and there are a few practical considerations that have to be taken into account. It is not a good idea to have lots of long wires trailing all over the place inside the case.

This is not just a matter of making the interior of the project look pretty. Long

wires can give problems with poor performance and could even result in a project failing to work. This type of thing tends to be more of an issue with analogue circuits where it is definitely a good idea to keep the input and output wiring well separated. Digital circuits are not immune to problems due to long wires, so it is advisable to keep the wiring reasonably short with digital designs.

Drawing

In order to draw up a front panel you are unlikely to need the more advanced drawing tools. Most front panels are rectangular, and there should be a tool for drawing basic shapes such as rectangles and circles. As pointed out in the previous article, it is essential to make use of rulers and (or) grids in order to get things the right size and positioned accurately. There is often the option of entering dimensions and angles from the keyboard, but it is generally quicker and easier to place an initial point on the screen and then drag the object to the required size. Complex shapes can be built up from individual lines and arcs, or there might be a Polygon or Polyline tool specifically for this type of thing.

Objects in drawing programs usually have outline and fill properties. In Serif DrawPlus 4.0 these are controlled by the panel in the right-hand section of the window (Fig.2). The main outline properties are the colour and line width. Very thin lines do not print well on most printers and might even fail to appear, but thick lines can effectively make the finished drawing a bit approximate. Use a line width that prints well but is thick enough to give "crisp" printouts. About 0·5 points is suitable for normal lines with one or two points being used for "heavy" lines. There will probably be various line types (dotted, dashed, etc.) which can be useful.

Fig.2. Serif DrawPlus 4 has a tabbed control panel that provides numerous line and fill options, plus a range of text features. Graduated fills (extreme right) are available but are best used sparingly

In-Fill

It will not be essential to use a fill colour. If you require a plain panel it is just a matter of opting for a suitably blank fill colour, which will usually be "white", "none", or "transparent". Drawn objects that mysteriously disappear are a common problem when first using a drawing program. What has usually happened is that a white fill has been used for the outline of the panel, and the missing objects are notionally behind this filling. This will not happen if a "transparent" fill or none at all is used. It is easily rectified anyway, and there is an Arrange menu that enables objects to be moved back or forwards so that the desired appearance is obtained. In this case the easiest solution is to select the panel's outline and then use the Send to Back option in the Arrange menu.

Of course, you are not limited to plain panels. When using a black and white printer you are limited to black and shades of grey, but a wide range of colours are available when using an inkjet type.

With most drawing programs you are not restricted to a simple solid fill. There is usually the option of using various graduated fills where there is a gradual transition from one tone to another, or even from one colour to another (Fig.2 extreme right). This type of thing can be quite effective when used sparingly, but psychedelic front panels are inappropriate for most projects.

Text

Initially it is probably best to draw up a simple template that can be used when drilling the front panel. This can be printed out and gummed to the panel. The panel and template can be soaked in water once the drilling has been completed, and it should then be easy to remove the template.

It is best not to use anything other than water based adhesives for this type of thing, especially when a plastic panel is involved. Apart from the likely difficulty in removing the template and adhesive, there is a risk of the adhesive damaging plastic panels.

Having designed the template, the drawing can be saved under another name and then worked on further to produce the proper overlay. Modern projects are often quite small, which means that the legends will frequently have to be in small type. Modern laser and inkjet printers are quite good at handling small type, but it is still advisable not to use a text size of less than about eight points.

Circles of the appropriate size can be used to represent the control knobs, and large front panel components such as meters or displays can also be drawn onto the design. This enables you to see precisely how much space is available for the labels, and should avoid having any partially obscured on the finished unit. The unwanted objects simply act as guides and are deleted once all the labels have been added.

The Text tool should have various alignment options, and in this case it is a centre or middle alignment option that is required so that the labels can be accurately centred above their respective controls. This is not guaranteed to provide perfect looking results every time, but some manual "fine tuning" can be used if you prefer to position things "by eye". Initially you have to guess at suitable text sizes, but any drawing program should enable text objects to be edited, including font and size changes.

The full range of installed fonts is normally available, so fancy lettering can be used if desired. However, with most projects a simple and "light" font such as Arial is a good choice. A full range of colours will be available if you are using a colour printer, but due care has to be taken when using coloured lettering. For lettering to be clearly legible it is important to have good tonal contrast between the text and background. In other words, use either dark lettering on a light panel or vice versa.

Contrasting colours with little tonal contrast tend to make text difficult to read. For example, mid-green text on a mid-red background (Fig.3 left) is likely to be hard on the user's eyes. Something like dark blue text on a light blue background (Fig.3 right) makes the text much easier to read. Good tonal contrast is especially important with small text. Some printers have problems with "bleeding" and poor results if light text is printed on a dark background. Dark text on a light background is a safer option, and this is again something that is much more important with small text.

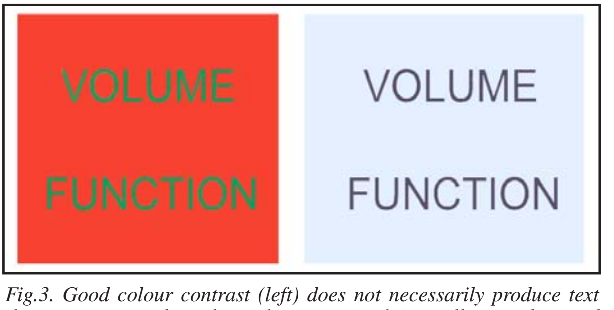


Fig.3. Good colour contrast (left) does not necessarily produce text that is easy to read. High tonal contrast (right) usually provides good legibility

Probably the most important thing when designing a front panel is to be in no hurry. Take a critical look at the finished design. Ultimately it is usability and practicality that are more important than good looks. There is no point in producing pretty designs where the components will not all fit into place properly or you need to be a contortionist in order to use the finished unit!

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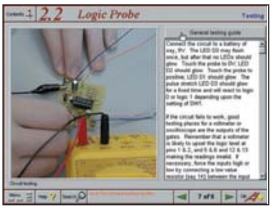
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

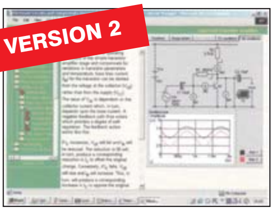


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

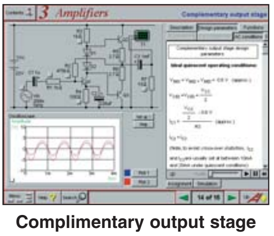
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

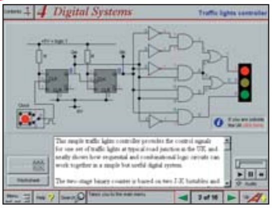


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

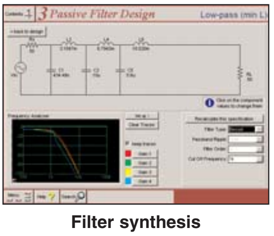
VERSION 2



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

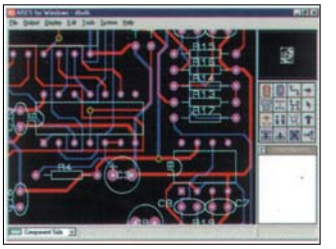
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev

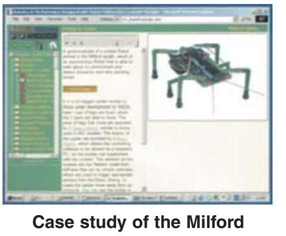
ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
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- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

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PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

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This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

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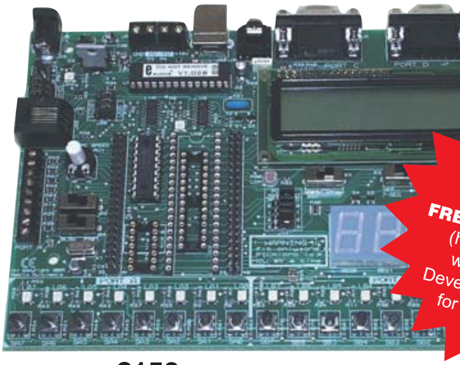
- USB programmable
- Can be powered by USB (no power supply required)



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SOFTWARE

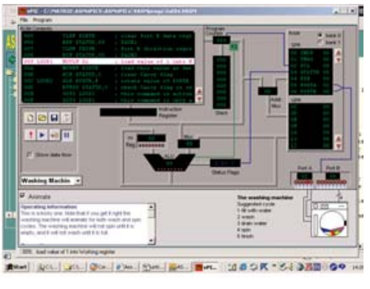
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



‘C’ FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.

Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro V2

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

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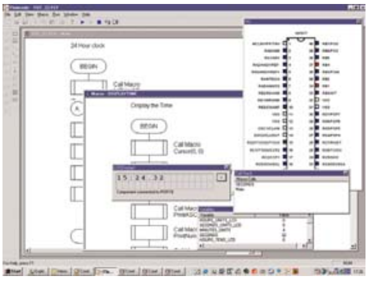

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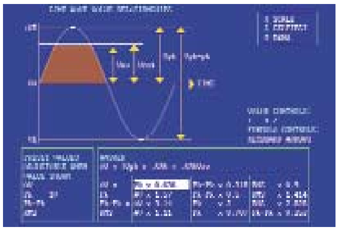

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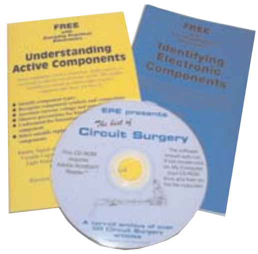

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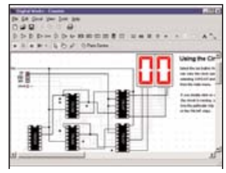

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Clean up your video signals with this:

Video-audio booster for home theatre

If your home theatre setup involves sending video signals over fairly long cables, you'll really appreciate this project. It's a wideband amplifier that can boost both composite and S-video signals, or even component video signals with the right cables. And it handles stereo audio signals as well.

By JIM ROWE

WHEN SETTING UP a home theatre, there's often a need to run fairly long video cables between your signal sources (DVD player, VCR and/or satelite receiver) and your big screen display. The reason for this is simple – it isn't always convenient to have the signal sources and the display at the same end of the room.

Of course, there's no great problem feeding audio signals over long cables, provided that the cables are of reasonable quality. However, that's not the case with video signals due to their much greater bandwidth. Video signal frequencies can range up to 5MHz or more (as against just 20kHz for audio) and can suffer quite noticeable degradation when fed through cables longer than about five metres.

This signal degradation is due mainly to cable capacitance. This causes high-frequency losses and occurs even when you use high-quality coaxial cable that has been correctly terminated at each end. The resulting pictures lack contrast and colour saturation, and also become noticeably "softer" (ie, lacking in fine detail) due to the lower bandwidth.

Video booster

The best way to tackle this kind of problem is to use a video "booster" every five metres or so. Basically, you take a 5-metre cable run and plug it into

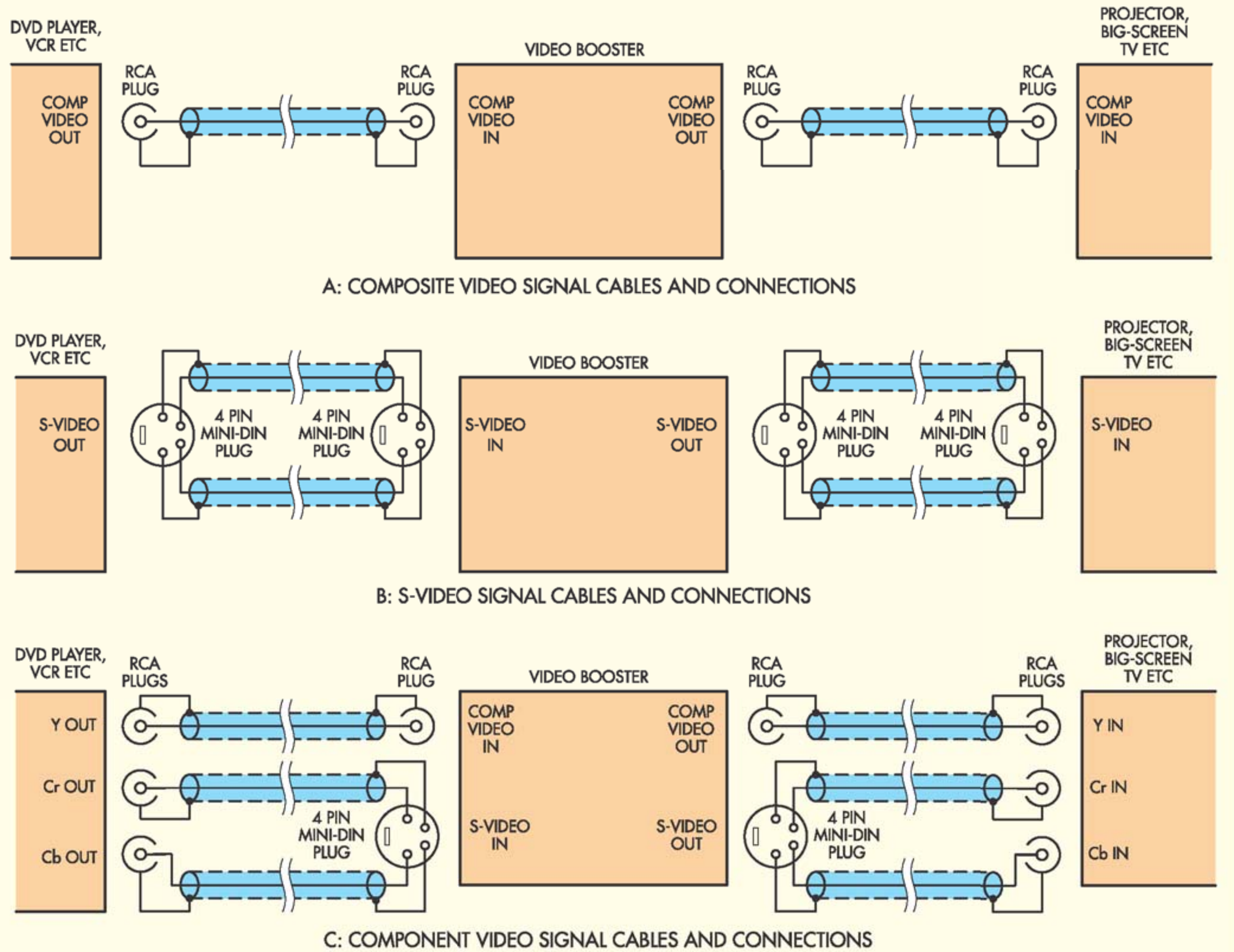


Fig.1: this diagram shows how the video booster is connected for composite video signals (top), S-video signals (centre) and component video signals (bottom). It's basically a matter of buying (or making up) the necessary cables.

the booster – essentially a wideband video amplifier. The booster restores the incoming signal so that it is close to the original before feeding it to the next 5-metre cable run and so on.

A booster for conventional "composite" video signals needs just a single wideband video amplifier channel. However, if you want to take advantage of the higher quality available from the "S-video" output of your DVD player, the booster needs two channels. That's because, in S-video, the luminance ("Y") or black-and-white picture information is not combined with the chrominance ("C") or colour information. Instead, the two signals are fed along separate cables to prevent them interacting – see Fig.1(b).

The video booster described here can handle either composite or S-video signals as required, because it uses an IC which actually contains four wideband amplifier channels. This allows us to devote one channel to the composite video input and output, while two more are dedicated to the S-video input and output sockets. This means that there's no switching and the composite video and S-video channels can even be used at the same time; eg, to pipe composite signals to another room while you're watching S-video signals on your home theatre display.

The fourth channel is spare and can only be accessed internally.

What about handling the even higher quality "component video" signal outputs? With this type of signal, as well as the luminance (Y) being kept separate, the two "colour difference" signals (R-Y or "Cr" and B-Y or "Cb") are also kept separate – ie, instead of being combined as the chrominance (C) signal.

If your DVD player provides these outputs and your display can also handle them, the video booster can help here too. All you need to do is buy or make up some adaptor cables, so that the three component video signals can be fed through the three main booster channels – see Fig.1(c).

Audio amplifier

As well as the video amplifier channels, the booster also includes a pair of low-noise audio line amplifiers. This means that it can also be used to handle any stereo audio signals which accompany the video, so these too will reach the far end of the cables in good condition.

Probably the main use for the audio channels will be where you're feeding the video and audio to a different room. They'll also come in handy if

Parts List

1 PC board, code 558, 117 x 102mm, available from the EPE PCB Service
1 plastic instrument case, 140 x 110 x 35mm
2 PC-mount 4-pin mini-DIN sockets
6 PC-mount RCA sockets
1 PC-mount 2.5mm concentric male "DC" connector
1 9V AC plugpack (500mA) with 2.5mm female connector

Semiconductors
1 MAX497 quad video amplifier (IC1)
1 LM833 dual op amp (IC2)
1 LM7809 +9V regulator (REG1)
1 LM7909 -9V regulator (REG2)
1 LM7805 +5V regulator (REG3)
1 LM7905 -5V regulator (REG4)
1 3mm green or red LED (LED1)
2 1N4004 1A diodes (D1,D2)

Capacitors
2 2200µF 16V PC electrolytic
2 100µF 16V PC electrolytic
2 10µF 10V PC electrolytic or tantalum
2 2·2µF 35V tantalum
2 1·0µF MKT
2 220nF MKT
4 100nF monolithic ceramic

Resistors (0·25W, 1%)
4 100kΩ 8 75Ω
2 47kΩ 2 10Ω
3 1kΩ

Where to buy a kit
The design copyright for this project is owned by Jaycar Electronics. Complete kits are available from Jaycar Electronics.

The A/V output sockets are all accessible from the rear of the unit. They include a 4-pin mini-DIN socket for the S-video signals, plus three RCA sockets for the composite video and left & right channel audio output sockets. The socket at far right is the DC power connector.

you need to send one or more of the signals in a 5.1, 6.1 or 7.1-channel surround sound system to remote power amplifiers; eg, you might want to send the SB (surround back) signals from your 6.1/7.1-channel decoder to the rear of your home theatre room, to drive a power amplifier for the rear centre speaker.

Alternatively, you might want to drive an active subwoofer with the LFE (low frequency effects) channel signals.

Presentation

As you can see from the photos, the booster is very compact. Everything fits in a small ABS instrument case measuring just 140 × 110 × 35mm. Power comes from a 9V AC plugpack.

Incidentally, Jaycar Electronics are making a complete kit for the booster available, so you should be able to build it up very easily and at an attractive price.

How it works

The booster's video amplifier channels are all provided by IC1, a Maxim MAX497. This high-performance device is designed expressly for handling video signals. It includes four closed-loop buffer amplifiers, each operating with a fixed voltage gain of 2·0.

Other features of the MAX497 include a full-power -3dB bandwidth of over 200MHz, exceptional gain flatness (±0·1dB up to 120MHz), low distortion, very low differential phase/gain error between the four channels and the ability to drive four back-terminated 75Ω (or 50Ω) output cables simultaneously.

As shown in Fig.1, we're using one amplifier for the composite video channel and another two amplifiers for the Y and C channels for S-video. Each amplifier has a 75Ω resistor across its input and these ensure correct termination of the cables from the video source. In addition, 75Ω resistors are used in series with each output to give correct "back termination" of the output cables.

As mentioned, the amplifiers in the MAX497 have a feedback-controlled gain of exactly two. This compensates for the attenuation produced by the interaction between the back termination resistors and the termination resistors at the far end of the output cables.

In effect, the Video Booster "restores" the incoming signal before feeding it to the next cable segment.

The input and output connections to the composite video amp channel are made via RCA sockets, as these are now standard for domestic equipment. Similarly, the connections for the S-video channels are made via 4-pin "mini DIN" sockets, as these too are the accepted standard for S-video.

Note that the fourth "spare" amplifier in the MAX497 is also provided with input and output termination resistors. This is done to ensure that it doesn't interact with the three active channels. The resistors will also make it easy to use the spare channel if you ever need it.

The two audio line amplifier channels are provided by the two halves of an LM833 dual low-noise op amp (IC2). As shown in Fig.2, these two stages are identically connected as non-inverting buffers, with the 100kΩ resistors providing negative feedback for a gain of two.

The performance of these audio buffers is quite respectable. They have a frequency response from 30Hz to 120kHz at the -1dB points, a THD (total harmonic distortion) below 0·006% for 2V RMS output, a signal-to-noise ratio of better than 91dB relative to 2V RMS output, and an output clipping level of just on 14V peak-to-peak (5V RMS).

The audio buffers operate with a gain of two to ensure sufficient signal to drive your remote power amplifiers, etc. However there may be cases where even this small amount of gain could cause problems – producing distortion due to input stage overloading, for example.

If that turns out to be the case with your particular application, there's a simple modification which can be done to solve the problem. All you need do is remove the 100kΩ resistors connecting pins 2 and 6 of IC2 to ground. This turns the buffers into unity-gain voltage followers, increasing the overload margin by 6dB.

Power supply

The power supply section is quite straightforward, even though the video and audio amplifiers require four separate DC supply rails. The MAX497 requires ±5V supply rails, while the LM833 require ±9V rails.

Because the overall current drain is quite low (about 100mA total), two simple half-wave rectifier circuits (D1 & D2) are used to derive nominal ±12·8V DC rails from a 9V AC plugpack. These rails are filtered using two 2200µF capacitors and then fed to 3-terminal regulators REG1 and REG2.

REG1 and REG2 produce the +9V and -9V rails respectively. They also drive 3-terminal regulators REG3 and REG4 which produce the ±5V rails. LED1 is driven from the +9V rail via a 1kΩ current-limiting resistor and provides power on/off indication.

The associated 100µF and 10µF capacitors are used to filter the regulator outputs. The ±9V supply rails are then further decoupled using 10Ω resistors and 2·2µF capacitors before being fed to IC2. Four 100nF capacitors provide additional filtering for the ±5V rails to IC1.

Construction

All the parts are mounted directly on a small PC board, so the unit is easy to build. This includes all the connectors, so there's no off-board wiring at all inside the booster box.

The PC board measures 117 × 102mm and is coded 558. It's double sided, with copper tracks on both top and bottom, but the top pattern is mainly an earthed ground plane. Only a handful of component leads are soldered to this top pattern, so we

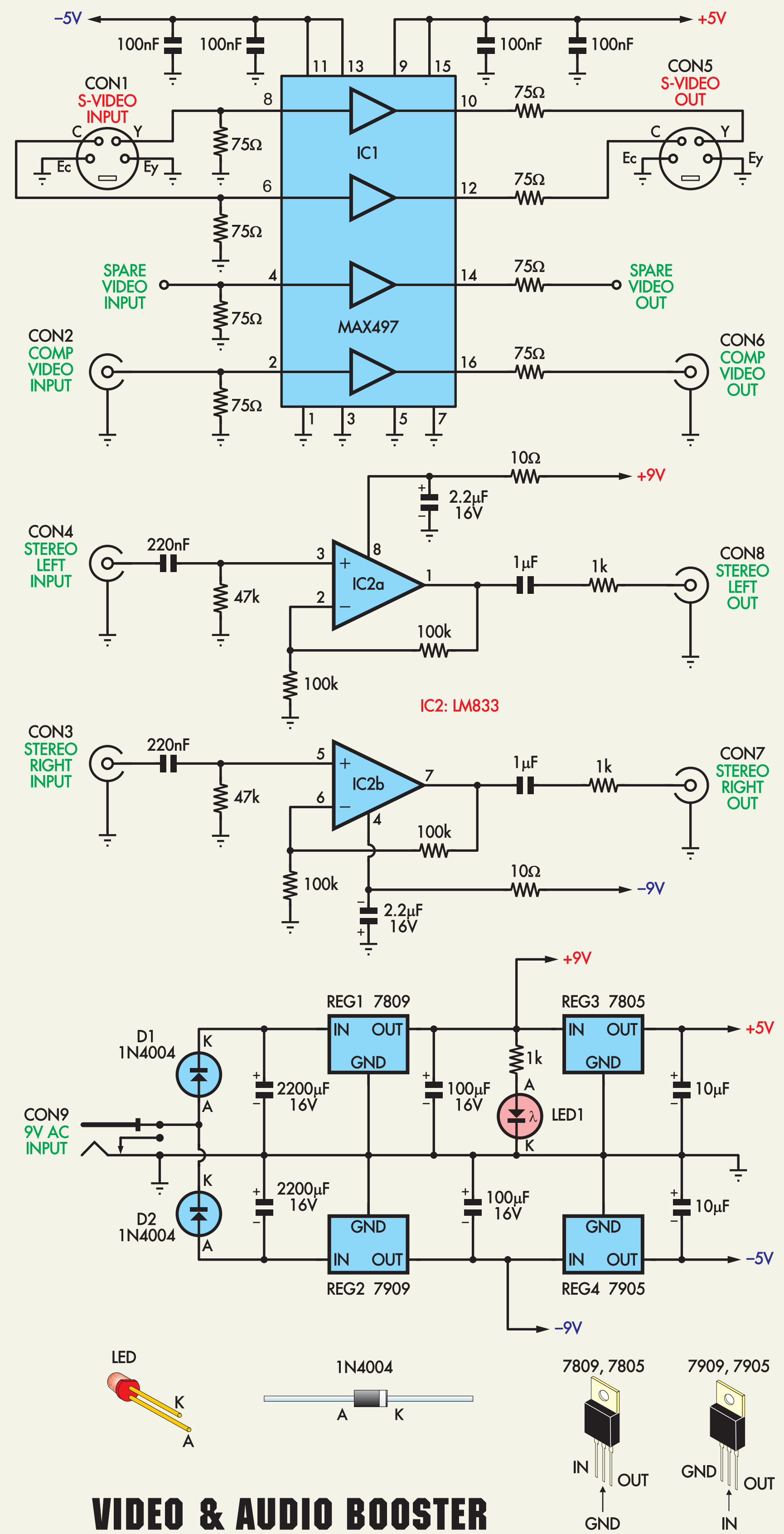
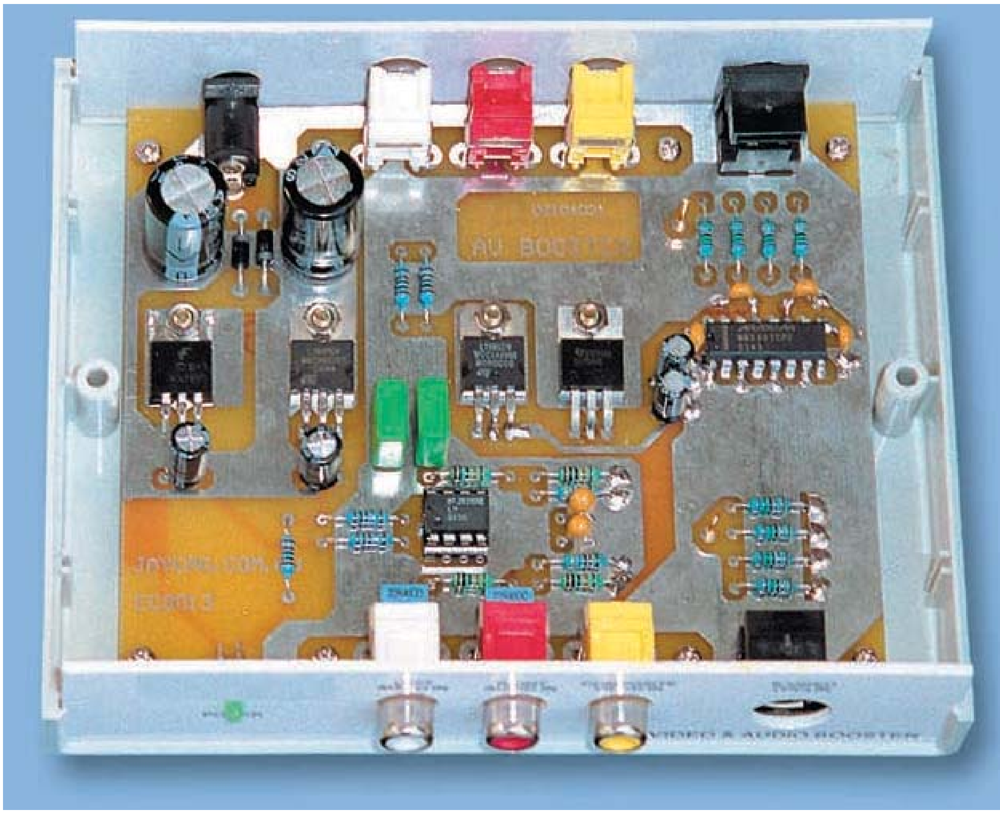


Fig.2: the booster circuit is based on a Maxim MAX497 quad video buffer IC (IC1). One amplifier in IC1 is used for the composite video channel, while another two are used for the Y and C channels for S-video. Op amps IC2a & IC2b (LM833) boost the left and right channel audio signals.



This photo shows how the power indicator LED is mounted on the PC board and pushed through a matching hole in the front panel.

Left: inside the completed booster unit. Keep all component leads as short as possible and be sure to solder the leads to both sides of the board where necessary, as indicated by the red dots on Fig.3.

don't need a board with expensive plated-through holes.

Fig.3 shows the assembly details. Begin by fitting all the input and output connectors, as they often need a small amount of juggling and pin straightening before they'll mount without stress. Make sure that they're pushed down hard against the board, while you make the solder connections underneath.

Next, fit the two PC board terminal pins (for the input and output of the spare video channel), followed by the resistors and the diodes D1 and D2. Be sure to fit each diode the correct way around as shown on Fig.3.

Note that some of the resistors have their "earthy" ends soldered to the top copper pattern as well as to the pad underneath. The leads concerned are shown with a red dot on the board overlay diagram.

The four voltage regulators can go in next. These are all TO-220 packages and are mounted horizontally on the top of the board. Be sure to fit each one in the correct position, as all four are different and mixing them up could result in component damage when you apply power.

All regulator leads are bent downwards 6mm from the package body. This allows you to mount them by pushing the leads down through the mating holes and then fastening their tabs down against the copper using 6mm × M3 machine screws and nuts. The leads are then soldered to the pads underneath and, in some cases, to the top pads as well – see Fig.3.

The two 2200µF capacitors and the two 100µF capacitors adjacent to REG1 and REG2 can go in next. Make sure you fit all of these polarised parts the correct way around, as shown in Fig.3.

LED1 is fitted with its "flat" cathode side to the left (ie, furthest away from CON4). To install it, first bend both its leads down 90 degrees, 6mm away from the LED body. That done, it can then be soldered into place with its axis exactly 8mm above the board.

Power supply checks

At this stage, it's a good idea to check all of the power supply wiring by plugging the lead from your 9V AC plugpack into CON9 and turning on the power. LED1 should immediately light and you can now check the regulator outputs. You should get +9V from REG1, -9V from REG2, +5V from REG3 and -5V from REG4. These voltages are all measured relative to board earth and at the righthand

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	4	100kΩ	brown black yellow brown	brown black black orange brown
❏	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	3	1kΩ	brown black red brown	brown black black brown brown
❏	8	75Ω	violet green black brown	violet green black gold brown
❏	2	10Ω	brown black black brown	brown black black gold brown

Table 2: Capacitor Codes

	Value	IEC Code	EIA Code
❏	1·0µF	1u0	105
❏	220nF	220n	224
❏	100nF	100n	104

pin of each regulator, as indicated on Fig.3.

If everything is correct, you can switch off and continue fitting the remaining parts to the PC board. Conversely, if one or more of the regulator outputs is incorrect, switch off immediately and check for wiring errors. Most likely, you'll have made a mistake fitting D1 or D2, one of the electrolytic capacitors or one of the regulators. With a bit of luck, you'll be able to fix the problem and not have to replace any parts.

Completing the PC board

The remaining parts can now be fitted to the board, starting with the MKT audio coupling capacitors, the 2·2µF tantalum bypass capacitors and the 10µF electrolytic capacitors. The two ICs can then be installed, taking care that you fit each one the correct way around.

Note that the pins for IC2 (the LM833) are only soldered to the copper pads underneath, while some of the pins for IC1 (the MAX497) are soldered to the top copper pattern as well. This applies to pins 1, 3, 5, 7, 9, 11 & 13.

The next components to fit are the two 100nF bypass capacitors, which are at each end of IC1. These mount with their "earthy" leads soldered to the top copper pattern as well as the pads underneath. That done, fit the two remaining 100nF bypass capacitors for IC1 and the remaining 10µF electrolytic capacitor for the -5V rail. As before their leads are soldered to pads on the top of the board, with their "earthy" leads soldered to the bottom pads as well.

Final assembly

All that remains now is to fit the booster board to the case.

First, you have to fit the front and rear panels over their respective RCA connectors, before lowering the three items together into the bottom of the case. That done, LED1 can be pushed into its 3mm mating hole on the front

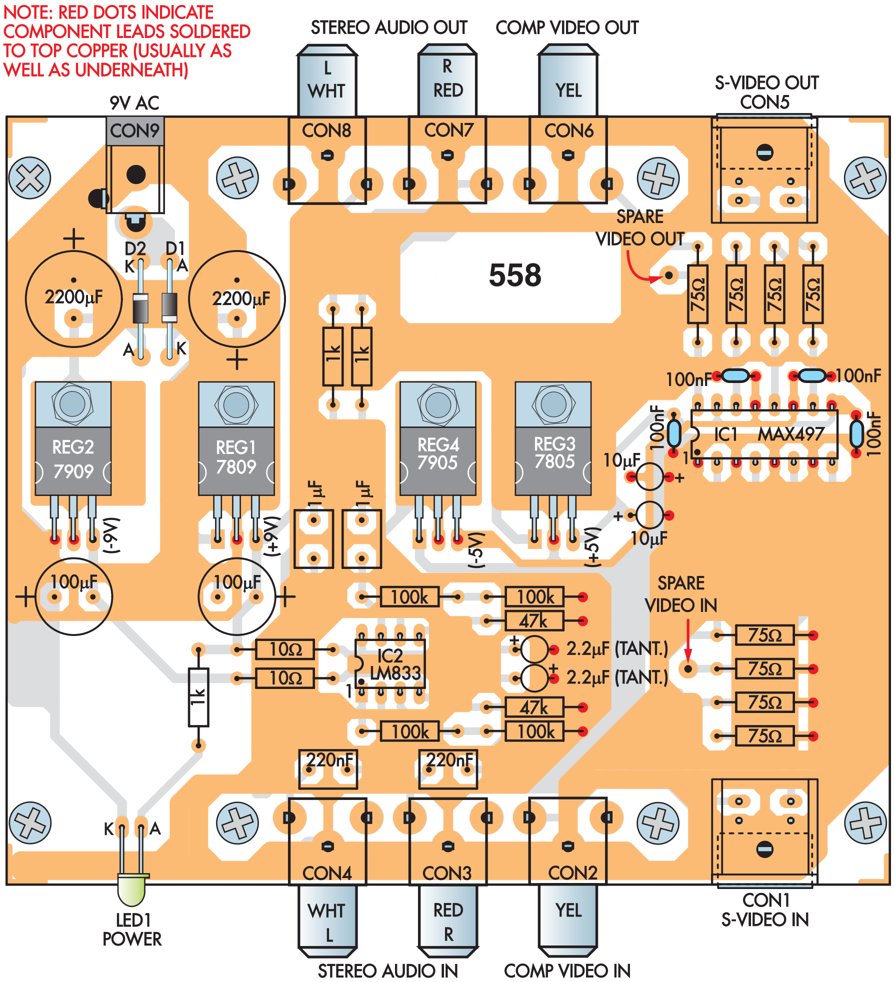


Fig.3: install the parts on the double-sided PC board as shown here. The red dots indicate where component leads must be soldered to the copper tracks on the top of the board (and usually underneath as well).

panel and the board secured to integral pillars in the bottom of the case using eight 6mm self-tapping screws.

Be sure to use all eight screws to secure the board. These give the board added support in the vicinity of the various input and output connectors.

The final step of all is to fit the top of the case, using the two long countersink-head self tappers provided. Don't lose these screws by the way, because they're a special size and surprisingly hard to get.

Your Video & Audio Booster is now finished and ready for use.

Component video cables

Before we end up, let's take a look at the adaptor cables required if you want to use the booster for component video signals.

There's nothing terribly complicated about this. All you need to do is buy or make up four cables – two for the luminance (Y) signals and two for the chrominance (Cb and Cr) signals.

The cables for the Y signals each consist of single lengths of coax with an RCA plug at each end. These connect to the booster's composite video channel, as shown in Fig.1(c).

The other two cables are each of double coax, with a mini-DIN plug connected at one end and a pair of RCA plugs at the other. They are used to carry the Cb and Cr chrominance signals and are connected to the booster's S-video channels.

Note that both RCA-RCA and 2 × RCA-miniDIN video cables are available from many suppliers. However, you may want to make up your own using high quality coaxial cable, to ensure lower signal degradation – especially if you have fairly long cable runs. Some prewired cables leave a bit to be desired in this respect.

By using the correct adaptor cables, the booster will operate just as effectively with component video as it does with composite video or S-video.

Happy home theatre viewing! ***EPE***

Regular Clinic

Circuit Surgery

Ian Bell

Shift registers can extend PIC output capabilities

AFTER several months of analogue topics, *Circuit Surgery* goes digital in response to a question ***Paul Goodson*** recently posted about shift registers on the *EPE Chatzone* (access via **www.epemag.co.uk**:

I would like somewhere to start on shift registers. I would like to use them to expand the output capabilities of PICs. Basically what I am after is to address different pulse width modulators (PWM) to an array of LEDs. I need 51 (17 × 3) outputs.

I have never used shift registers as such and I need to learn how to from scratch. I have looked up a lot of types and would like to play around with some, but it's just knowing where to start, as there seem to be a lot.

There were various contributions discussing the merits of different shift register devices and methods of driving LED arrays, but we will look at the basics of shift registers and go on to consider their use in expanding the output capabilities of microcontrollers such as PICs.

Serial Data

Serial data transfer, where data is sent one bit at a time down a single wire, or via some other medium, such as a radio link, is being used to an ever increasing extent for moving data both within and between electronic systems. Where radio and phone links are involved the reason is obvious – you would need multiple phone lines or transceivers/channels to send data in parallel.

In other cases, maybe the reason may seem less obvious – why do PCs use serial buses such as USB to connect to peripherals rather than parallel links? Surely parallel transfer would be faster as more data could be sent at once? There are various reasons for using serial for such purposes.

Firstly, the wiring is simpler and smaller – you need typically two to five conductors to send data, whatever its size is (8-, 32-, 64-bit etc), and possibly power as well. Secondly, although parallel transfer seems simpler there are technical difficulties at very high speeds, including making sure that all lines have the same delay so that the data bits are not skewed, and the difficulties which can occur with supply current transients if large numbers of bits are switched at once.

Paul's idea of using serial data transfer to extend the output capabilities of a PIC is by no means unusual. Many microcontrollers, including the PIC series, have standard serial interfaces – namely the Inter Integrated Circuit (I^2) bus and the Serial Peripheral Bus Interface (SPI). You can of course also send and receive serial data by appropriately "bit bashing" any digital I/O pins in software.

Serial Examples

Readers of John Becker's and Mike Hibbert's articles in *EPE's PIC n' Mix* column will recall that a serial approach is often used to transfer data between the PIC to peripheral devices. In recent months we have seen the DS1307 real time clock which uses the I^2C serial bus, the DS1267 digital potentiometer, which uses a shift register approach and the 25C256 EEPROM which uses the SPI interface. The SPI bus was described in detail in *PIC n' Mix* January and Febuary 2006.

The shift register is a key component in serial data systems. We can use shift registers to convert serial data to parallel by loading in serial data and outputting in parallel. We can also use shift registers to convert parallel data to serial by loading the data in parallel (as in a multi-bit normal register) and shifting out in serial form.

Flip-Flop

The basic building block from which shift registers are made is the "flip-flop". The flip-flop is a 1-bit memory and occurs in a variety of forms. Here we will just look at the *edge triggered D-type flip-flop with asynchronous reset*, symbols for which are shown in Fig.1.

It has three inputs, R, D and C and two outputs Q and $\overline{Q}$. The Q output is equal to the value stored by the flip-flop and $\overline{Q}$ is the complement (logical inversion) of this value. The R (Reset) input when asserted (it may be either active high or active low) causes the stored value, and hence the Q output, to go to logic 0 (typically 0V). The $\overline{Q}$ output will go to logic 1 (typically the supply voltage) when it is reset. The reset is described as "asynchronous" because it is not under the control of the C (Clock) input.

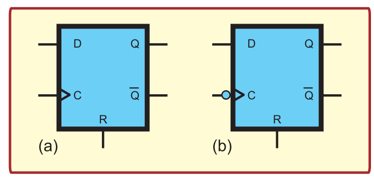


Fig.1. Edge D-type flip-flop schematic symbols: a) postitive edge-triggered; b) negative edge-triggered

On the other hand, the D (Data) input can only change the stored value (and outputs) under the control of the clock (C). Specifically, the flip-flop will store the logic value present on D when C *changes*. This is why the device is called "edge-triggered". The little triangle by the C input on the schematic symbol indicates that the input is edge-triggered.

If the device is a positive edge-triggered flip-flop, D will be stored on the 0 to 1 transition of C. If it is a negative edge-triggered flip-flop, D will be stored on the 1 to 0 transition of C. Negative edge triggering is indicated by the inversion bubble at the clock input as shown in Fig.1b.

Basic Shift Registers

The most basic form of the shift register is called a SISO (Serial In Serial Out) shift register and is simply a "chain" of D-type flip-flops as shown in Fig.2a. On each clock edge data is passed from each flip-flop to the next one in the chain. Note that although all the flip-flops change at the same time there is a delay from the clock edge to the Q outputs actually changing, this holds the old data on the input of the next flip-flop in the chain long enough for it to be read. The data in the final flip-flop is "lost" unless it is stored in another part of the circuit. The first flip-flop is connected to the serial input (labelled SDI - Serial Data In) in Fig.2b, and the last flip-flop's Q output is the serial output (labelled SDO).

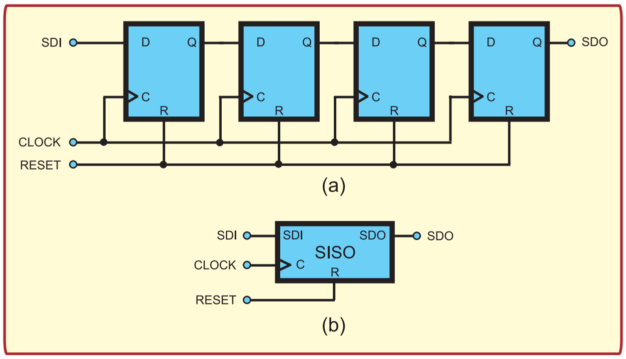


Fig.2. Serial In Serial Out shift register: a) schematic; b) symbol

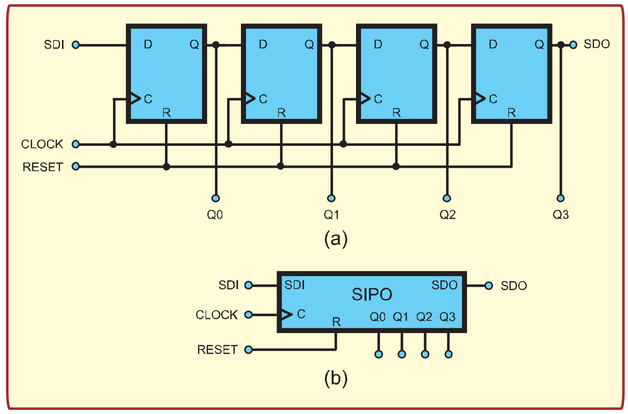


Fig.3. Serial In Parrallel Out shift register: a) schematic; b) symbol.

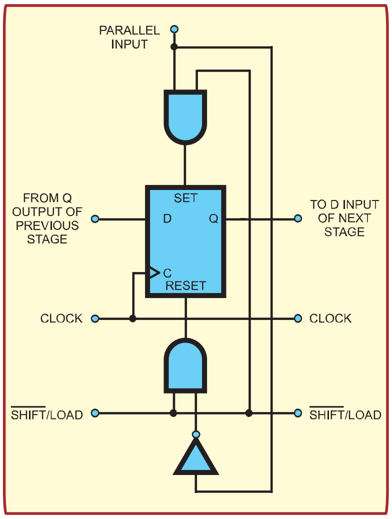


Fig.4. One stage of a parallel (PISO) load shift register

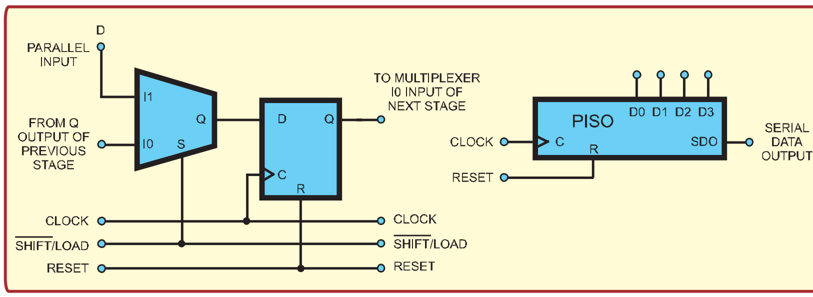


Fig.5. Alternative parallel load shift register and 4-bit PISO symbol

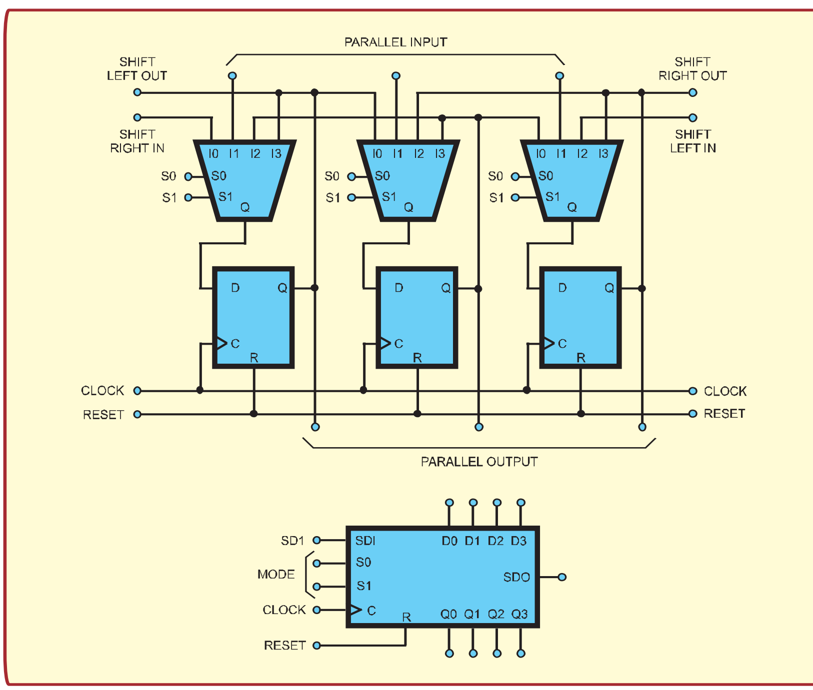


Fig.6. Three-stage (parallel/serial, in/out left/right), four mode shift register

To obtain a parallel output from a shift register, we take the Q outputs from all of the flip-flops, giving us a Serial In Parallel Out or SIPO shift register. This is shown in Fig.3. This can convert serial data into parallel outputs and is the form of shift register most likely to be used for extending PIC or other microcontroller outputs.

Shift registers may also have parallel inputs (so that we get PISO and PIPO shift registers) and could be used to extend the input capabilities of a PIC or other microcontroller. Parallel input requires some extra circuitry, and one form of this is shown in Fig.4 (one stage is shown, these are repeated to form the complete shift register).

If the shift/load line is low, the circuit acts as a shift register, shifting data on the clock edge. When the shift/load line is high, the parallel input directly influences the asynchronous set/reset inputs of the flip-flops. On the negative transition of the shift/load, the data at the parallel inputs is latched into the shift register irrespective of the state of the clock input.

Another approach to parallel loading uses a multiplexer on the D input of each flip-flop. This is shown in Fig.5 where shift/load selects either the previous stage (when it is high) or the parallel input (when it is low) for connection to the flip-flop's input. Unlike Fig.5, the loading is synchronous. When shift/load is low, data is loaded on the clock edge.

Two-way Traffic

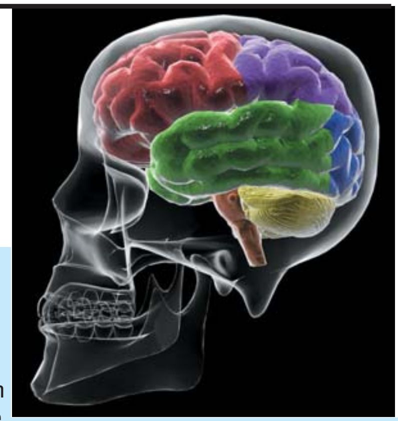
Sometimes we may want to shift in both directions using the same register. This is easily achieved by using an extension of the multiplexer arrangement. Three stages of a shift register which has four modes of operation are shown in Fig.6. The four modes are selected by the four inputs of the multiplexers connected to the flip-flops' inputs. The mode controls are common to all the multiplexers. The modes of operation are shown in Table 1. This type of multi-function shift register is sometimes called a universal shift register.

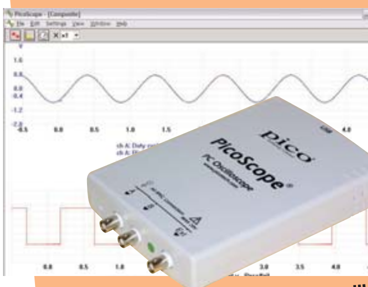
Table 1. Universal shift register operations

SO	SI	Operation	Input
0	0	Shift right	I0
0	1	Parallel load	I1
1	0	Shift left	I2
1	1	Hold	I3

The "story" continues next month.

Ingenuity Unlimited





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Dog Alert – *Reinforced Intruder Hounding*

THE inspiration for this circuit came in the middle of the night when the dog next door began barking at something that disturbed it. Now that's what good watchdogs do, and the reason that, apart from the companionship, so many people keep a dog in or around the home as a deterrent to would-be intruders.

To reinforce that deterrent, it seemed it would be a good idea to have a light switch on at the same time to give the impression that the occupants have been alerted to their dog's warning bark. The Dog-Alert does just that. It will switch on a porch or interior light when the dog barks, and remain on for a short period of time. It could also be a boon for the hearing impaired person.

Circuit Details

The simple circuit diagram shown in Fig.1 uses readily-available components. MIC1 is an electret microphone whose sensitivity is set by the value of resistor R1. These two components form a voltage divider.

Op.amp IC1 is connected as a differential amplifier. When its two inputs receive an equal voltage, there is no voltage at output pin 6. But if, say, one input is 2·2V and the other is 2·3V, the difference is 0·1V. By the same token, if one is 5·4V and the other 5·5V, the result is still the same 0·1V. When there's a voltage differential between the two inputs, caused by MIC1 responding to sounds, this is detected and amplified to provide an output voltage. Capacitor C1 and resistor R4 provide a momentary lag at inverting input pin 2 to obtain the differential, which produces a negative-going pulse at output pin 6.

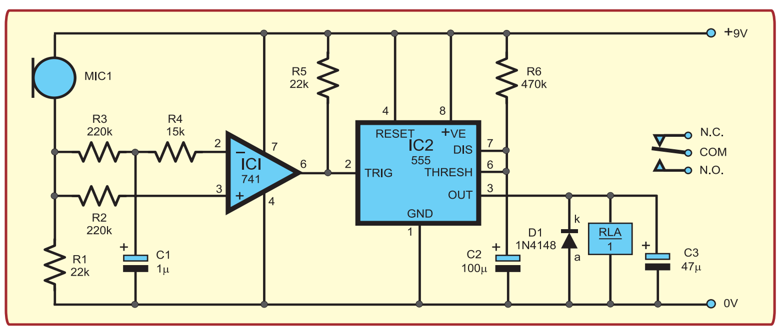

Fig.1. Full circuit diagram for the Dog Alert

Timer IC2 is configured conventionally. Its timing cycle commences when trigger pin 2, biased normally-high by resistor R5, is taken low by the op.amp's output. Capacitor C2 and resistor R6 determine the timing period. With the values shown, this will be approximately 50 seconds. Other timing periods may be obtained by increasing or decreasing the value of C2 and/or R6.

Relay RLA interfaces the circuitry with mains lighting or other equipment. The mains connections should only be made by someone suitably experienced or qualified.

For reliable results, the Dog-Alert should be operated from a mains power pack and be located within proximity of Fido's sleeping quarters.

Tony Lee, Old Reynella, South Australia

PICO PRIZE WINNERS

Once more it's time to decide the lucky winners of superb PC-based Oscilloscopes, generously donated by Pico Technology, to whom we extend our appreciation for sponsoring the cloumn again. For more information about Pico's range of test equipment visit their web site at **http://www.picotech.com**, or see their advertisement elsewhere in this issue.

Mike Kenward and John Becker considered all Ingenuity Unlimited entries published over the last twelve months, and the prizewinners are: **Winner** – receives a superb PicoScope 3205 Digital Storage Oscilloscope worth £586: *GPS/Audio Selector* by George Caldwell, Londonderry (*EPE* June 2005) – **Runner-Up** – a Pico DrDAQ Data Logger/Scope worth £59: *TV Standby Monitor* by A.D. Beech and M. Robertson, Chasetown (*EPE* July 2005)

READOUT

Email: john.becker@wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly.

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★ LETTER OF THE MONTH ★

Talking Santa

Dear EPE,

Attached is a photo of a Talking Santa which I have made, based around Mike Hibbett's *Halloween Howler* project in the October '05 issue. It uses a pair of 5mm blue LEDs for the eyes and when an unsuspecting person walks past it, they are greeted with "Ho Ho Ho Ho! Merry Christmas Everyone!" and the eyes lighting up!

The project was an interesting surprise to relatives who visited over Christmas, since it is not obvious that it "speaks" (especially when placed among other Christmas decorations).

Jonathan Grainger, via email

Hi Jonathan, how splendid that is. I sent it on to Mike Hibbett as well.

Pond Side Greetings

Dear EPE,

I refound your magazine in a book store in Kingman Arizona USA. The reason I say "refound", is that I read your magazine years ago, and am glad that it still exists. Alas, many of the US publications, *Radio Craft, Popular Electronics*, etc. went extinct years ago. Just glad to see that you are still around.

I am fascinated by all facets of radio, including ham 49MHz radio, F.R.S. radio, crystal radio sets, etc., and am interested in the state of the art for hobby electronics as it exists now. Radio Shack (they should change the name) has passed electronic hobbyists here in the US. I know that you have Radio Shack in UK.

Allan Egleston, KF6UXJ, USA, via email.

Thank you Allan, welcome back!. Unfortunately Radio Shack no longer operate in the UK either.

EPE's New Format

Our change of format has produced reader response. Thank you all for your feedback. Here are a few of the comments.

Regarding the *EPE* format, my experience is similar to that of David Parkins (Jan '06 *Readout*). Many of my favourite magazines revised their format shortly before they ceased publication, so like David I get a bit apprehensive every time a magazine changes its format. Fortunately, many magazines stay in business after a format change, and going out of business does not follow a format change quite as often as thunder follows lightening.

Probably like David and many other readers, I seek a relatively "serious" magazine rather than an "entertaining" magazine. I began subscribing to *EPE* precisely because the old format announced: "the content is more important than the facade", and for me, the change of format is relatively unimportant. I particularly dislike "glamorous" magazines that are little more than press releases urging me to buy something. Fortunately, you seem to have designed the new format very carefully, and it probably announces: "the content is important, and with modern technology we can give you a pretty facade too".

I think it is useful for all readers to remind ourselves that magazines don't only need us, they need advertisers, and to recruit and retain advertisers the publishers need to convince those advertisers that the magazine has lots of readers that will buy lots of stuff.

This I'm sure is a big motivator behind the format change. Although readers like David and I are very nice people, because we are a bit "serious" we think a lot about anything we might buy, and we probably aren't the ideal reader to attract advertisers. I think all publishers do their homework and have discovered that people who buy "entertaining" magazines are bigger spenders than people who buy "serious" ones.

I think we "serious" readers should be grateful for this. If the magazine can attract more "big spenders" it can attract more advertisers and then it can publish more interesting articles and we can enjoy a better magazine. I am sure that the new design isn't perfect, but it seems very suitable and I think it is reasonable for us all to be optimistic.

Keith Anderson, Tasmania

I think we can now see why you are preferring to publish articles in association with *Silicon Chip* rather than reader submissions.

I'm sorry to see that you have dropped the "where do you get awkward components" mini column. If *SC* is sourcing components in Oz, you may need to restore it!

I really enjoy reading *EPE* from cover to cover and support many of your advertisers, and buy binders, CDs, PCBs from you too!

Phil Warn, Orpington, Kent

With most components now being available from advertisers and distributors like Rapid, Conrad, Farnell and RS we hope you won't have any buying problems. We are also encouraging advertisers like Jaycar and Magenta to make kits for projects available.

Wooaw! I like the new look of the magazine, especially the cover. It looks more modern and better related to new technology/electronics than before. Congratulations and kepe up with the good work. Now we can judge the magazine by its cover.

Kypros Vassiliou, Cyprus

All at C Feedback

*We have received a fair bit of response to the letters from David Parkins and Dr Jim Arlow in the Jan '06 issue, both as direct mail, and via our Chat Zone (access via **www.epemag.co.uk**). Here is a selection of the feedback:*

I have been following the C *vs* assembler debate with much interest, it looks like it could become almost religious in the zealousness with which the extremists in each camp attack the opposition. I have a point of view which is in between, so probably both sides will attack it with equal fever.

The best way of learning about programming a micro is to understand at the instruction level what is going on, to do that you have to learn to program in assembler, it also helps that debuggers and single stepping program code are nearer to the action so to speak when the source code is in assembler. That said, for complex programs us humans work better with abstracted models and so C or Java make for quicker code development and less systematic errors.

There is, however, a big IF in all this, that is knowing how what you write will actually affect the microcontroller. In large machines with operating systems, high level languages make a lot of sense because the operating system is there to sort out the detail of hardware and memory access and the operating system interface is protected by access checking and address checking routines and the like. It is important to remember that there is a lot of assembly language programming in device drivers even on the PC, both Win XP and Linux, just look at the libraries that ship with your compiler.

Small PICs like the 10F, 12F and most of the 16F range are best programmed in assembler simply because they don't have the resources to make C perform efficiently. Of course, for the large devices like the 18F and the new 24F and dsPIC, C becomes a very good option. Even more so for devices like the ARM7 etc.

However, there is a halfway house, the Microchip assembler is a macro assembler and supports many compile time directives, this means that you can write code that is just abstracted enough to make the human writer comfortable but still compact, efficient and easy to debug on the target machine.

Let's not argue and abuse each other, we all are after the same thing, enjoying practical electronics, try to see the other side's point of view. Most engineering is a compromise in order to find a way of making the materials to hand do what we want at a reasonable cost, so if a 12F508 will do the job with 300 bytes of assembler should we really use a 16F628 with 2k of C? Conversely if you find yourself struggling with a 50 page assembler listing then try C, it might save your sanity.

Finally, please don't abandon assembler, introduce C alongside it. Anyone who is trying to debug some time critical function in C will eventually resort to the assembler that the compiler has produced, and having found that the general case is slowing them down, have to write that routine specifically in assembler, the alternative would be faster clocks and bigger processors.

In industry we have to cost reduce products to make a profit in the competitive market, one of the first places that we look is can we make the processor as small and cheap as possible and yes we write in assembler to get there – silicon area costs in every product shipped, the programmer's time is amortised over the life of the product, it is just another engineering compromise.

John Dunton, Haverhill, Suffolk

I realise that JB prefers PIC assembly language to C or Delphi, etc. but it would be nice if perhaps in a special or supplement you could also give prominence to C.

As some one who lives for computers and started off with KDF9 assembly, then System 4 assembler, then ICL 1900 assembler, then Z80, then 808X8 assembler, I am not exactly biassed towards C, Delphi, Fortran, Algol, etc.

But, C is out there, in your advertisers' pages, etc. Not all can get on with Assembler, you know! Don't just stick to assembler.

Phil. Warn, Orpington, Kent

As mentioned by Dr. Arlow, memory space is available to consume (rather than conserve) but what if the object code is close to the limit and then modifications/additions present themselves later? Also, in the case of volume production, disregard for memory size might entail moving up to a larger, more expensive member of the PIC family and could also lengthen the time to download the code from PC to PIC.

The most important argument for me, though, is first to consider the type of application. Embedded "firmware" (that's really what PIC code is) will be chosen as a means of directly controlling/accessing an electronic circuit but without recourse to a vast array of conventional logic chips. The individual steps in that control procedure are significant and also the PIC runs at low speed compared to a PC.

Timing is often an important part of firmware design. If the requirement is non-critical as far as timing goes and if the high-level language offers access to the necessary PIC facilities, fine. For other applications where timing has to be of known precision, writing in assembler gives the programmer full control over the number of cycles taken by the chosen sequence of instructions.

Many years ago I was briefly involved in a hospital computer system programmed in Coral-66. This looks like a structured high-level third-generation language but, in truth, it's unusable unless there is a good understanding of the way that it compiles into machine code. There aren't any input/output instructions, machine-dependant low-level subroutines need to be provided by the programmer for these functions.

So what's the answer? Depends on what you're trying to achieve. If the high-level language produces inefficient code at a place where a compact routine is required, then this is where assembler is still needed. The worst case would be a high-level programmer, familiar with the wide-open-spaces and huge resources of a fast PC, writing in this same style for embedded firmware on a slow processor with limited memory, but where the input/output interface requires direct control.

Godfrey Manning BSc, G4GLM, Edgware, Middx

I am a professional programmer who has taken up PIC programming as a hobby. I have used many low and high level programming languages over the years. I concur wholeheartedly with the readers who have written in and stated that C is preferable to assembler.

After building the AmQRP PIC Elmer 160 Project Board (**www.amqrp.org/elmer160/board/index.html**) and taking the excellent PIC Elmer Tutorial (**www.amqrp.org/elmer160/board/index.html**) I thought I was ready to program my PIC projects in assembler. I built a PIC16F84A based time delay circuit that replaced a big hunk of equipment containing transformers and time delay relays. I built a digital thermometer using a PIC16F684 and an LCD readout, then switched to a 3-digit LED readout just to see how it was done. These projects were all coded in assembler and I thought I was doing well.

I chose the PIC16F877A for my current project because I needed lots of I/O. The 877A has plenty of code and data memory, but there are four pages of code and four banks of data memory. After writing a few thousand lines of code, my program was crashing and I was spending all my time figuring out what code page and data bank to select.

It had become a nightmare. So I decided to shop around for a C compiler, and purchased a full-featured one at a very reasonable cost for a single user. I rewrote my code in C and what a difference! Small, compact modules. No worries about where the code and data are. And it's easy to insert chunks of assembler code. My nightmare was gone and I was able to finish my project.

I can also say that high level languages are far easier to understand and maintain than low level. And the code is far more portable. Consider how hard it would be to port a PIC assembler program to another type of processor, compared to C code.

Thanks for the interesting magazine, and keep up the PIC projects!

Jack Botner, VE3LNY

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FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF *EPE*

All prices include UK postage

Computing & Robotics

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver
If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and Home editions.
The book was written with the non-expert, busy person in mind. It explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.
The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, Notepad and Paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; How to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

268 pages **Order code BP514** **£7.99**

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold
Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton
Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages **Order code NE36** **£16.99**

INTRODUCTION TO MICROPROCESSORS
John Crisp
If you are, or soon will be, involved in the use of microprocessors, this practical introduction is essential reading. This book provides a thoroughly readable introduction to microprocessors. assuming no previous knowledge of the subject, nor a technical or mathematical background. It is suitable for students, technicians, engineers and hobbyists, and covers the full range of modern microprocessors.

After a thorough introduction to the subject, ideas are developed progressively in a well-structured format. All technical terms are carefully introduced and subjects which have proved difficult, for example 2's complement, are clearly explained. John Crisp covers the complete range of microprocessors from the popular 4-bit and 8-bit designs to today's super-fast 32-bit and 64-bit versions that power PCs and engine management systems etc.

222 pages **Order code NE31** **£21.99**

EASY PC CASE MODDING
R.A Penfold
Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages **Order code BP542** **£8.99**

NEWNES PC TROUBLESHOOTING POCKET BOOK – THIRD EDITION
Howard Anderson, Mike Tooley
All the essential data for PC fault-finding and upgrading. This book provides a concise and compact reference that describes, in a clear and straightforward manner, the principles and practice of fault-finding and upgrading PCs and peripherals. The book is aimed at anyone who is involved with the installation, configuration, maintenance, upgrading, repair or support of PC systems. It also provides non-technical users with sufficient background information, charts and checklists to enable the diagnosis of faults and help to carry out simple modifications and repairs. In order to reflect rapid changes in computer technology (both hardware and software) this new edition has been completely revised and rewritten.

256 pages **Order code NE41** **£19.99**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps
A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation.

Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

320 pages **Order code NE38** **£26.99**

Testing, Theory and Reference

THE AMATEUR SCIENTIST
CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.
Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.
Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.
Includes extensive Science Software Library with even more science tools.
Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.
Over 1,000 projects **Order code AS1 CD-ROM** **£19.95**

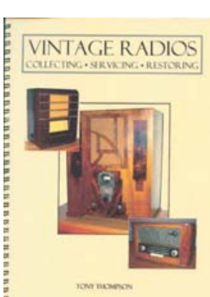
BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

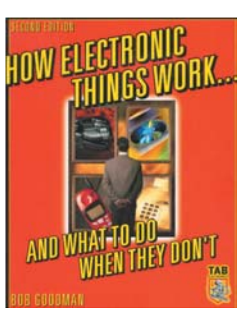
This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!
Over 800 pages in Adobe Acrobat format **Order code BEB2 CD-ROM** **£21.95**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.
In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
96 pages **Order code BP239** **£5.49**

OSCILLOSCOPES – FIFTH EDITION
Ian Hickman
Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.
This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.
The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.
288 pages **Order code NE37** **£22.99**

PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain
To be a real fault finder, you must be able to get a feel for what is going on in the circuit you are examining. In this book Robin Pain explains the basic techniques needed to be a fault finder.





Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.
The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.
274 pages **Order code NE22** **£25.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money
In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.
The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.
206 pages **Order code PC109** **£9.95**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explainend, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages **Order code PC106** **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop
Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.
Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.
The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.
228 pages **Order code NE35** **£20.99**

HOW ELECTRONIC THINGS WORK – AND WHAT TO DO WHEN THEY DON'T
Robert Goodman
You never again have to be flummoxed, flustered or taken for a ride by a piece of electronics equipment. With this fully illustrated, simple-to-use guide, you will get a grasp on the workings of the electronic world that surrounds you – and even learn to make your own repairs.
You don't need any technical experience. This book gives you: Clear explanations of how things work, written in everyday language. Easy-to-follow, illustrated instructions on using test equipment to diagnose problems. Guidelines to help you decide for or against professional repair. Tips on protecting your expensive equipment from lightning and other electrical damage. Lubrication and maintenance suggestions.
Covers: colour TVs, VCRs, radios, PCs, CD players, printers, telephones, monitors, camcorders, satellite dishes, and much more!
394 pages **Order code MGH3** **£21.99**

VINTAGE RADIOS – COLLECTING ● SERVICING ● RESTORING
Tony Thompson
The essential guide to collecting, repairing and restoring vintage valve radios. These receivers are becoming ever more popular as collectibles, this is a good thing because it means that a very large piece of technological history is being reclaimed when at one time many thought it lost forever. If you look around, you will find plenty of valve radio sets just waiting for a loving restoration. They may not yet be the most highly prized, and they are unlikely to be in top condition, but they can be yours and, if you develop the skills outlined in this book, you will possess radio receivers to be proud of.
The book covers radio history, styling, faultfinding, chassis and cabinet restoration, types of set.
124 pages spiral bound **Order code TT1** **£13.50**

All prices include UK P&P

Project Building

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.49**

BUILDING VALVE AMPLIFIERS
Morgan Jones
The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.
A unique hands-on guide for anyone working with valve (*tube* in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.
Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£21.99**

STARTING ELECTRONICS, THIRD EDITION
KEITH BRINDLEY
A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.
A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.
Breadboarding layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£10.99**

Theory and Reference

COIL DESIGN AND CONSTRUCTIONAL MANUAL
B. B. Babani
A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

96 pages **Order code BP160** **£4.49**

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

188 pages **Order code BP299** **£5.49**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold
Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to the individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

138 pages **Order code PC116** **£5.45**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold
Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£5.45**

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard, Amex, Diners Club or Maestro to:

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PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photocopies of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.

A large number of older boards are listed on our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Keyring L.E.D. Torch	AUG '04	456	£4.12
★Teach-In '04 Part 10 – PIC Curtain or Blind Winder		457	£5.39
Simple F.M. Radio – F.M. Tuner		458	£5.07
– Tone Control		459	£4.75
– Audio Power Amp (TDA2003)		347	£4.60
– Power Supply		460	£5.39
★EPE Scorer – Control Board		461	£6.66
– Display Board		462	£7.93
– Slave Board		463	£5.55
★PIC to Mouse/Keyboard – **Software only**		–	–
EPE Wart Zapper	SEPT '04	464	£4.60
★Radio Control Failsafe		465	£4.76
★AlphaMouse Game		466	£4.60
★Rainbow Lighting Controller – **Software only**		–	–
★Moon and Tide Clock Calendar	OCT '04	467	£5.55
Volts Checker		468	£4.20
★Smart Karts – **Software only**		–	
Logic Probe	NOV '04	469	£4.76
Thunderstorm Monitor		470	£5.39
MW Amplitude Modulator			
– V.F.O./Buffer		471	£4.76
– Modulator/PA		472	£5.07
– Power Supply		473	£4.76
Super Vibration Switch	DEC '04	474	£4.75
Wind Direction Indicator		475	£6.18
★PIC Flasher Mk2 – Control Board		476	£4.75
– Transmitter		477	£4.44
– Multipurpose Board		478	£4.75
– Simple Cycler		479	£4.44
– Luxeon V Controller		480	£4.44
– Power Supply		473	£4.76
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★Camera Watch		482	£6.03
Gate Alarm – Oscillator		483	£4.92
– Delay/Timer		484	£4.92
★Sneaky – Transmitter	FEB '05	485	£4.60
– Receiver		486	£4.91
★PIC Electric Mk2 – Control		487	£5.87
– Sensor		488	£5.71
Sound Card Mixer		489	£7.29
Headphone Monitor	MAR '05	490	£5.71
EPE Cat Flap		491	£6.02
★Bingo Box – Main		492	£9.04
– Big Digit Display		493	£10.31
Spontaflex Radio– Tuner	APR '05	494	£5.55
– Coil Pack		495	£5.71
– Audio Amplifier		496	£5.55
– Tuning Capacitor Board		406	£4.28
★Safety Interface		497	£6.18
Back-To-Basics 1– Fridge/Freezer Door Alarm		498	£5.39
★Crossword Solver	MAY '05	499	£6.66
20W Amplifier Module		500	£5.14
Back-To-Basics 2 – Water Level Alarm		501	£5.39
– Burglar Alarm		502	£5.87
★PIC Ultrasonic Scanner	JUN '05	503	£6.66
★Radio Control Model Switcher		504	£5.87
Back-To-Basics 3 – Scarecrow		505	£5.55
– Digital Lock		506	£6.66
CompactFlash Interface Board		507	£6.66
LF/VLF Converter	JUL '05		
– Fixed Capacitor Board		508	£5.71
– Mixer/Oscillator Board		509	£5.86
– Buffer Amplifier		510	£5.23
– Q-Multiplier		511	£5.23
– Tuning Capacitor Board		406	£4.28
Back-To-Basics 4 – Doorchime		512	£6.34
– Electronic Dice		513	£6.02
★Cybervox		514	£6.82
Multi-Clap Switch		515	£6.66
Audio System	AUG '05		
– Preamplifier		516	£6.02
– Mic. Supply Board		517	£5.23
– Power Amp		518	£6.02

PROJECT TITLE		Order Code	Cost
★Pain Monitor	AUG '05	519	£7.14
MotorAmp		520	£7.45
Back-To-Basics 5 – Kitchen Timer		521	£5.87
– Room Thermometer		522	£6.02
All-Band Radio – Full Version	SEPT '05	523	£5.71
– Mini Version		524	£5.23
★Multicore Cable Tester – Main		525	£6.19
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Back-To-Basics 6 – Daily Reminder		527	£6.19
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